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RESEARCH FOR BETTER NUTRITION.*

BY

HENRY C. SHERMAN,

Mitchill Professor of Chemistry, Columbia University, New York, N. Y.

Mr. President, Mr. Secretary-Director,
Members and Guests of The Franklin Institute:

Your award is appreciated more highly and deeply than I know how to say. Yet I must accept it in behalf of others as well. The research which it honors is the work of much more than any one person: co-workers have collaborated through several years, Columbia University has made the work possible, and foundations have aided with annual grants at times of particular need.

For this meeting I have been asked to tell what I can in 15 minutes about the nutrition research in which we of the chemistry department at Columbia have been engaged for the past 30 to 40 years. Obviously this can be but a sketchy account of our experimental researches, without discussion of social-economic or civic and governmental application. Yet, speaking in the shadow of Franklin, I cannot but be challenged by both the key words of his favorite phrase: "*philosophical* and *useful* knowledge."

We were engaged in the presumably "useful" work of studying food chemistry and the nutritional adequacy of food supplies. At the same time a more "philosophical" interest led us to investigate the chemical natures of enzymes, the catalysts that make chemical reactions in the body run fast enough to support the processes of life. Then came a rapid series of discoveries, through simultaneous work in several laboratories, that established the existence of a group of substances—the

* A talk presented at the Medal Day Meeting at The Franklin Institute, April 17, 1946. A more complete article on the subject will appear in a forthcoming issue of the JOURNAL OF THE FRANKLIN INSTITUTE.

(Note—The Franklin Institute is not responsible for the statements and opinions advanced by contributors in the JOURNAL.)

vitamins—important to both the main lines of work upon which we were engaged.

Like the enzymes—in fact, largely as constituents of tissue enzymes—the vitamins function by catalyzing the chemical processes of life. And the vitamins function also as nutrients in the more usual sense and thus become important factors in the whole world problem of the adequacy of food supplies to nutritional needs, and, through the nutritional improvement of the life process, to the attainment and longer maintenance of the higher levels of human health, efficiency, and accomplishment.

This is not to say that the nutritional improvement of life processes and life histories rests entirely on the vitamins, but rather that through their discovery the chemist has been enabled to study all food factors—whether vitamins, amino acids, or mineral elements, or their combinations—more comprehensively and precisely through quantitatively planned and controlled nutritional experimentation, than had previously been possible or even anticipated.

In addition to the significance of each of several vitamins as the key to a previously baffling disease, these discoveries have sufficiently rounded out the chemist's qualitative knowledge of the substances needed for normal nutrition to permit him to undertake such quantitative questions as: What kinds of food contain a given nutrient *in what relative amounts? How much* of it is needed? And, more ambitiously, How much yields *best* results?

And this last question becomes a group of questions according as one or another phase or segment, or the whole, of the nutritional life history—or even the record of experimental families through successive generations—is taken as the criterion in judging the merits of foods or food supplies.

Time does not permit full explanation of the fact that our new knowledge of nutrition rests firmly upon the bases both of scientifically studied human experience and controlled experimentation with animals of species selected through research as reacting like human beings in the phase of nutrition under investigation.

A great deal of today's research for better nutrition deals directly with studies of nutritional status in human beings and the general advances summarized here rest largely upon this direct human evidence. But inasmuch as the whole history of what we call the newer knowledge of nutrition covers only about one-half as many years as a normal human lifetime, the direct studies of human beings are necessarily of the nature of separate cross-sections at different segments of the life cycle. For the experiments in which whole lives are studied continuously throughout, we must use species whose nutritional chemistry is sufficiently like our own, yet whose normal life-cycles are much shorter.

Thus our present knowledge as a whole rests on strong evidence obtained consistently both from direct human experience and controlled animal experimentation, and so verified experimentally and scrutinized statistically as now to be regarded as having moved forward from the realm of opinion to that of objectively established scientific fact.

In experiments of this comprehensive kind, the approach is chemical, the reagent is the whole body, and the reaction is the whole nutritional life history. The experiments still observe the principle that only one significant factor is to be varied at a time. Yet they are set up in two ways according as the experimental variables are: isolated chemical substances; or articles of food such as nature and agriculture produce and people (and other animals) actually consume.

In the researches of which we are now speaking, it was experiments in which the variable factor was the quantitative proportions of natural foods that first brought conclusive evidence of the constructive possibility of improving already-adequate diets or food supplies, and thus bettering the normal life process and the life history, through wiser, nutritionally guided, use of food.

A certain food mixture called *Diet A* was found *adequate* to the support of normal nutrition generation after generation; yet *Diet B*, differing only in its proportion of protective food, has been found to result in *better* life histories. Growth and development are (not forced, but) beneficially expedited, vitality is higher and death-rates lower at all ages, full adult capacity or "prime of life" is attained earlier and retained longer, and the life-expectation is increased not only for the young but also for the adults. The previous general progress of public health had increased the life-expectation of the infant but not of the grown person. Now, the nutritional improvement of the norm raises the life-expectation of the adult as well. The extra years thus offered are not to be pictured as added to old age. Rather it appears that something like an extra decade can be inserted at the prime or apex of the life lived in accordance with today's newer knowledge of nutrition. Life becomes longer because it is lived on a higher health level throughout. The apex of attainment is higher, the period of the prime is longer, and in human terms there is a smaller percentage of years of dependence, in the improved life history to which nutritional knowledge now guides us.

The one experimental variable of the above-cited work with Diets A and B involved, in terms of individual substances, enrichments of the diet in calcium, vitamin A, riboflavin, and protein. To the extent that the established improvements in nutritional life-history can be referred to one or more of these chemically isolated substances, we obviously gain both in breadth of understanding and in guidance to best use of other foods.

Recently, therefore, the larger proportion of our long-term feeding researches have been designed with one or another of the above-mentioned chemical factors as the experimental variable.

The effects of different calcium contents of diet both upon body composition and life history have been studied extensively and with fairly clear-cut results.

Our basal Diet A is adequate to the support of normal health, generation after generation. Yet when its calcium content is doubled, without other change in the diet, the life history is improved at every stage. As in the series first described, growth and development are expedited, vitality is higher with death-rates lower at all ages, and both the length of life and the period of the prime are extended.

Similarly, we have studied the effects of increasing the vitamin A value of the diet. That of the original Diet A has supported normal life histories through 60 successive generations, but without permitting the accumulation of more than a minimal bodily reserve. When the amount in the diet is doubled, there is improvement over the already normal life-history and family history throughout. We are now studying even more liberal allowances.

Riboflavin and protein seem to be interrelated, making a more complex situation that is still being studied experimentally.

Many isolated substances, and many natural articles of food, should be studied independently by the same general method of comprehensive, long-term experimentation. It is decidedly not to be assumed that the wide margins found beneficial with some nutrients are beneficial with all. Each will need to be studied experimentally on its own merits.

The fact that research for better nutrition has in recent years brought an unprecedented and unexpected increase in human ability to improve normal life processes and life histories may be attributed fundamentally to two advances. Science has liberated itself from a too dogmatic view of the fixity of the body's internal environment, and it has so developed the comprehensiveness and precision of its research methods as to obtain a new order of insight into life processes and nutritional life history.

Both the liberating concept and the elaboration of experimental method will doubtless be more fully developed by further research. For here it can now be seen clearly, as Francis Bacon said of experimentation, that it is "both for the illumination of the mind and for the amelioration of man's estate."

Also it becomes increasingly clear that this new knowledge, through its increase of human efficiency and its guidance of the use of food production resources, can implement our progress in social justice, diminishing the tensions of economic disparity and improving the prospects of permanent peace, both within the nation and between the nations.

TEAMWORK IN RESEARCH.*

BY

HENRY THOMAS TIZARD, K.C.B.; C.B.; A.F.C.; F.R.S.; Hon. D.C.L. (Durham).

President of Magdalen College, Oxford University, Oxford, England.

The extremely kind citation that accompanies the award to me of the Franklin Medal, an honour that I shall always highly prize, prompts me to say a few words on this occasion about the circumstances in which my aeronautical work has been done, and the men with whom it has been my great good fortune to be associated.

My interest in aeronautics started in 1915 when I joined the Central Flying School at Upavon, Wiltshire, as a junior experimental officer of the Royal Flying Corps. The science of aeronautics was then in its infancy; the British Advisory Committee for Aeronautics, as it was then called, was only six years old, and your own National Advisory Committee on Aeronautics was in process of formation. There were a good many aircraft of a kind in existence,—I learnt to fly in a Maurice Farman,—but practical success up to that stage owed very little to science, as we usually understand it, but was due in the main to men like the Wrights who had little or no formal scientific education, but possessed the rarer qualities of courage, adventure, and an ardour to experiment. That is the way great new industries arise. They may have their roots deep in the science of the past; they are fertilised by the science of the present; but they sprout from adventure.

In those days there were practically no accurate observations of the behaviour of aircraft in flight. There were plenty of data obtained by experiments on models in wind tunnels; but as was subsequently realized, these were liable to be most misleading to designers. Even now, with all the work that has been done since, deductions from tests of models must be regarded with suspicion until they are confirmed by large scale experiment; but at least we know the limitations. In 1915 we did not. Such knowledge as we had of behaviour in flight was largely derived from the impressions of young pilots; and the impressions of the average pilot, untrained in accurate observation, were too often wrong and expressed in unintelligible language. For instance, the fact that the needle of the old fashioned compass behaved erratically in cloud, and that one frequently came out upside down, was commonly attributed to the magnetism of clouds.

* Read at the Medal Day Meeting, Wednesday, April 17, 1946, by Mr. W. Laurence LePage. This is a synopsis of Sir Henry Tizard's paper which will be published in full in a forthcoming issue.

It soon became so obvious that progress would depend on full scale experiments, that some scientists, of whom I was one, learnt to fly at Upavon and at Farnborough. Not without a struggle, however; for the military chiefs of the day first objected on the grounds that we should be delaying the production of real pilots, needed for the war. In my own case permission was at last reluctantly given by the War Office on the condition that I should only be allowed to fly when the weather was unsuitable for ordinary training; a valuable discipline, mitigated by a sensible Commanding Officer who did not enforce it too strictly. From then on we could get on with the work faster; but not fast enough, for there were too few of us, and equipment was meagre. There was a great change when Bertram Hopkinson appeared on the scene, in charge of all experimental work. He was Professor of Engineering at Cambridge, a great son of a great father, robust in body and mind, possessing to a supreme degree the unusual combination of acute scientific powers and a practical flair for doing the right thing. He taught us, in his own words, to study the things that mattered in the air. He was killed in a flying accident in 1918. All of us who worked under him, and have been able to contribute anything to the advance of aeronautics, know how much we owe to his inspiring leadership.

My own work, first at Upavon, and later at the experimental station at Martelsham Heath, Suffolk, which Hopkinson founded, was largely concerned with the development and application of methods for measuring the performance of aeroplanes, and with the study in flight of stability and manoeuvreability, and of fuel consumption. It was all done by quite simple methods, but it was of value at the time, and, I think, laid the foundations for the better methods that have been evolved since. And it was all team work; we were a happy band at Martelsham Heath, and I look back on the time I spent there with pleasure.

Towards the end of the war I came to know H. R. Ricardo, who had been a pupil of Hopkinson's at Cambridge. The then specification for aircraft fuel was based on the composition of gasoline extracted from Pennsylvanian crude oil, apparently on the very natural assumption that nothing that came out of Pennsylvania could be bettered. So aromatic hydrocarbons were rigidly excluded from the specification, and were believed to be bad for internal combustion engines. The shortage of gasoline, due to the submarine campaign, forced us to seek other sources; and the only indigenous source was gas tar which was largely composed of aromatics. Much to everybody's surprise, preliminary experiments showed that benzene and toluene, far from being deleterious, were very good fuels. After the war, I was associated with Ricardo in a wider attack on the problem. He designed and built what was, I suppose, the first experimental unit with variable compression, and soon succeeded in demonstrating the superior antiknock qualities of aromatic hydrocarbons. This led Pye and myself to study in detail

the self ignition of combustible compounds when suddenly compressed, on which we based what seemed to be a reasonable elementary theory to account for knocking. We used for this purpose special experimental equipment designed by Ricardo. But our work was soon completely eclipsed by the discovery, by Midgeley and Boyd, of the antiknock properties of lead tetra-ethyl; a discovery which led to a great advance in science and practice, about which I need not remind an American audience, for so large a part of the work has been done by American scientists and engineers.

About the same time we developed the thermodynamic theory of the internal combustion engine, and showed among other things why the maximum power did not sensibly change with large variations of the fuel/air ratio, a matter of great practical importance. I wonder how many people realise that the automobile and aircraft industries would probably not be in existence to-day, and certainly not on the present scale, unless Nature had conveniently arranged that carbon dioxide should dissociate at temperatures far below the maximum temperatures reached in the cylinder of an internal combustion engine!

Since then my direct contributions to the science of aeronautics have been slender, for I have been mainly engaged in administrative duties. I regret this, but I have never felt that I had the originality that justifies and deserves a life wholly devoted to research. I have managed however to keep in touch with developments as a member and later as Chairman of the British Aeronautical Research Committee. My tenure of the Chairmanship coincided with the revolutionary change in design from biplane to monoplane construction, a change which was greatly facilitated not only by B. M. Jones' theoretical investigations but by his full-scale experiments on the flow of air over wings in flight. It coincided too with a great advance in aircraft engine design, culminating in 1942 in the first flight of an aircraft powered with Whittle's jet propulsion engine. So it was a very interesting time, which was made all the more pleasant and fruitful by the cordial relations we had with our colleagues on your National Advisory Committee, and at Langley Field. We certainly never enlisted their help without getting it in full measure. I do not think that you could find in either of our countries a better case of team work between Universities, Government organisations, and manufacturers for the benefit of an industry, nor in the whole world a happier example of international goodwill and collaboration.

Our own Aeronautical Research Committee was not concerned with problems of air warfare, but in 1935 a special Committee was set up by the British Air Ministry to advise on Air Defense. The original scientific members of the Committee were P.M.S. Blackett, A. V. Hill, H. E. Wimperis and myself; but it may be of interest to record that it was not a Committee of scientists only, but a joint enterprise between scientists and officers of the Royal Air Force and of Anti-Aircraft

Artillery Command. It was this Committee that adopted Robert Watson Watt's suggestions for the use of radio pulses to detect and locate aircraft, and was responsible for the rapid development of the new method under his direction until its practicability was proved beyond doubt. It was not until five years later that we found that radar, as it is now called, had been independently invented in America about the same time, and that both nations had been ignorant of the other's work; which shows that scientists can sometimes keep secrets even among themselves, although they do not like doing so. It was this Committee, too, that organised full scale experiments on interception long before radar was in operation, and that introduced the method of ground control of aircraft, so that not only radar, but the new tactics based on its use, were ready in time for the Battle of Britain. All this involved team work of a high order, and of a special kind, which, though warmly encouraged by some senior officers, was regarded with suspicion by others. But what prejudice existed was soon broken down by success. The fashion spread; and a notable feature of the war, which distinguished it from all previous wars in which Britain has been engaged, was the collaboration on all planes, in all three Services, often informal but always close, of civilian scientists and fighting men in the study of the tactics and even of the strategy of war. Without such collaboration I feel confident that much time would have been wasted, and much scientific effort misdirected, which with our limited supply of men and resources we could not afford. One of the chief causes of the German failure was the absence of similar team work.

But the greatest example of team work of all has been that between American and British scientists and engineers in the war years. How much that has contributed to victory we must leave to historians to judge, in a better perspective view than we can enjoy. But what is significant, I think, is that regarded merely as an industrial effort both nations have gained, and neither has lost anything, by the free interchange of ideas and experience. Here is a problem for the future. Pure science, like all the highest intellectual pursuits of man, has known no national boundaries. We must all do our best to preserve this tradition. In applied science America has given to other nations more than she has taken from them. And yet many of the barriers that were swept away by the war are already up again, and tongues are tied, and intercourse restricted. The argument is that unless secrecy is imposed, national interests will suffer, and individual enterprise, on which industrial progress has depended so much in the past, will be discouraged. It is not an easy problem to solve; but the peace and prosperity of the world depend on its solution.

A LAYMAN'S VIEW OF LAW AND LABOR.*

BY

JAMES CREESE,

President, Drexel Institute of Technology, Philadelphia, Pennsylvania.

My predecessors in this lectureship, Mr. Morris Llewellyn Cooke and Mr. Ralph Flanders, set two or three good precedents for me.

I follow their good example by beginning these remarks with a word of thanks to the founder of this lectureship. The men who have stood here, by your invitation, on previous occasions, Mr. Cooke in 1944 and Mr. Flanders in 1945, may have had the advantage of a more intimate acquaintance with Mr. Day, with Mr. Day's life work, and with the ideals of public service which he demonstrated in his professional work and for the furtherance of which this lectureship of the Franklin Institute has been established.

As I understand, it was the intention of those who instituted this lecture foundation to remind us from time to time by these annual lectures that professional men, particularly the scientists, engineers, and managers of industries, have social and economic repsonsibilities of some magnitude, that each has a debt to society beyond all that he owes to himself and to his profession, to his employers and to his stockholders.

I undertsand, too, that the founders chose not to prescribe that spokesmen here under this lectureship are expected to accept any one fixed doctrine of industrial philosophy. They did not set up for the lecturers a creed, nor was it stipulated that we must pass certain tests of orthodoxy. The freedom given us proposes in itself certain reasonable restraints and tends to discourage reckless and unconsidered speech.

The previous lecturers have also indicated certain precedents as to the conclusions that are likely to be reached by a Charles Day lecturer.

I have read the interesting papers presented from this desk by my predecessors, Mr. Cooke and Mr. Flanders. These are contemplative essays on the subject of the public responsibilities of all of us, no matter what callings we follow.

Examining the lives of several men of affairs whom he admired, the first lecturer, Mr. Cooke, undertook to identify "the sometimes overlooked sources of power" in the intellectural equipment of a business executive. He took his examples from the lives of certain of his friends,

* Presented under the Charles Day Lecture Foundation of The Franklin Institute of Pennsylvania, given in the Hall of The Franklin Institute, at the Stated Meeting held May 15, 1946.

Mr. Baldwin, Mr. Ray, Mr. Gates, and Mr. Day. He described these as men who had never left off study, men who had not closed their books, and who, therefore, had not closed their minds, men who took an active part in public life and who in the administration of their private affairs were directed by a sense of public responsibility.

Mr. Flanders, in his paper last year, presented a catalog of the scientific achievements and inventions evoked by the war. He described the new contrivances to facilitate travel and communication; the advances in medical science; the labor-saving gadgets—telephones that will receive your messages for you and record them, "packaged" kitchens and "welded" houses (for which presently Mr. Ford or somebody will, no doubt, produce a schedule of turn-in values). He named among the new conveniences an underwear sensitive to heat and cold which of its own accord will open its knitted pores to tropic day and close them again against the desert night.

His recitation of the wonders of science was not composed, however, to lead us to the conclusion that the chief end of man is to achieve a maximum increment of labor-saving devices. Instead, he warned that the *wonders* of science might turn out to be the *horrors* of science. This conclusion of his was shortly thereafter to be demonstrated forcibly and fearfully at Nagasaki and Hiroshima.

The moral of Mr. Flanders' lecture was almost precisely that of Mr. Cooke's: that in our personal careers and in our public responsibilities, all gains may be losses if we are not inspired by a sense of justice and a realization of the common destiny of men.

Scientists who can read the formulas of our day admonish us, as did the prophets of Biblical times, that the kingdom of our power and happiness is divided and will pass to the Medes and the Persians to be destroyed. It is said by them in many ways that unless we can contrive to relate our ideals of humane government to our skill in technology, then we shall "live in fear, sleep in fear and die in fear."

One is almost tempted to believe that there is but one conclusion to be drawn by all Charles Day lecturers, past, present, and to come. There will be travel by different routes in our discourses, but we come, all of us, to the same destination, affirming that new elements of justice and mediation are required in the world, and that it is the function of the layman, particularly of the layman disciplined by thought and professional experience, to initiate the procedures which will lead to greater industrial and greater international peace.

There is a third precedent set for me by my predecessors. They chose subjects which would allow them to roam over a considerable territory in their speech-making.

When the officers of the Franklin Institute graciously invited me here I accepted in all innocence, believing that I would have something more than a month in which to consider what I would say. I was

quickly disillusioned, for I was asked to phrase my topic for publication in announcements to be printed at once.

It is a foolhardy parent who names his brain child before it is conceived. What is called "Jack" may turn out to be a "Jill." The only safe course is to pick an hermaphroditic or an ambiguous cognomen.

The begetter of a speech resolves his dilemma also by a gesture of ambiguity.

If he is an Admiral he says that he will speak on "The Past, Present and Future of the American Navy." That gives him ample room for manoeuvering when at length he puts to sea at such a bridge as this. If the man who is caught is Mr. Cooke, he tells the Secretary of the Franklin Institute that he will speak "On Some Commanding Aspects of the American Man of Business." And Mr. Flanders, a year later, meets the emergency by confining his speculations to "Some Technical Developments of the War and their Effects in Peace."

With less agility than my predecessors but still meaning to reserve to myself an ample terrain, I agreed more than a month ago to take as my subject "A Layman's View of Law and Labor"—that's pretty good; it stakes out an extensive claim, it permits the innocent meanderings of the amateur, giving such latitude as is allowed by the law and such horizontal and vertical dimensions as the two kinds of labor organizations aspire to.

The lay figure, whose view I presume to take, is himself an officer of the law.

This Layman carries no mace. He wears no wig. He has no search warrant or police badge, but he is a potent officer of the law. It is the Layman's custom and the Layman's will that the law expresses. It is only with his consent that the law can be enforced, and it is he who sits in the jury room to determine whose guilt for what breach of the law shall meet with punishment. The power of the law arises from the will of the people. No prohibition set by statute will long endure if it conflicts with the moral judgment, the social habits, or the basic rights of the Layman. He is the beneficiary of the law, but he is also its originator, and he becomes its final judge.

He is an onlooker in court but not merely an onlooker.

The antics of W. S. Gilbert's Lord Chancellor amuse us. We know the secret of his absurdity. He claims too much. We are amused by the predicament in which the high law lord finds himself:

> "The law is the perfect embodiment
> Of everything that's excellent,
> And I, my lords, embody the law."

We may wish it were true that the law really were the complete and perfect embodiment of everything that is excellent; but we do not

accept anyone's statement that excellence is truly embodied in the law of any moment or that any individual in power embodies the law.

There is a story of Justice Holmes told by Mr. Charles A. Beard, who is the Justice's junior by several years. I had the story from Mr. Beard years ago while the incident was fresh in his mind. He said he was in Washington and went to call on Justice Holmes, thinking that this might be his last chance. In the course of his conversation he remarked, "Justice Holmes, I have an impertinent question to ask of you. I would like to know if in your long experience on the bench you have found any single simple bit of philosophy that has guided you in your decisions?"

"Yes," said the Justice. "Yes, young man, I have. About fifty years ago I discovered that I am not God, and if an abattoir in St. Louis or a public utility in Vermont seeks to do something, and the question of restraints by the law arises, then I search the Constitution, and if I do not find there any absolute prohibition then I say 'Why! damn it, let them try.'"

Our respect for the law does not imply an unquestioning reverence for it. Law is man-made. It has admittable human imperfections. Many of the most important certainties and perfections lie outside the written law. Most of what we do is done without specific sanction of statute, without assurances of earlier adjudication, and without the force of a formal judgment by a court or a judge. We go about our business 99 days out of 100 without thought of the law, negotiating our concerns and composing our controversies in accordance with our own best judgments and as circumstances will permit us to do. We are content to believe that if ever action in law should become necessary, then common practice and precedents of the past or the common sense of the judges will acknowledge the reasonableness of what we have done.

One important excellency of the law lies in its flexibility and in the smoothness with which today it fits the approval or consent of society to the acts and to the needs of the individual. The judge on the bench, even the wise and conscientious judge, who has had experience in a thousand cases, finds it difficult to say by what process he comes to his judgment:

"What is it that I do when I decide a case? To what sources of information do I appeal for guidance? In what proportions do I permit them to contribute to the result? In what proportions ought they to contribute? If a precedent is applicable, when do I refuse to follow it? If no precedent is applicable, how do I reach the rule that will make a precedent for the future? If I am seeking logical consistency, the symmetry of legal structure, how far shall I seek it? At what point shall the quest be halted by some discrepant custom, by some consideration of social welfare, by my own or the common standards of justice and morals?"

These are questions asked by a great scholar of the law who served as Chief Judge of the highest court of the State of New York and as an Associate Justice of the Supreme Court of the United States.*

A series of questions so specific and so complete as these, suggesting in simple phrases the whole range of history, precedent, and logic from which the law derives, questions so unpretentious and even so humble, could hardly be devised by a man of little experience. Without in the least minimizing the imperatives of statute and precedent, without failing to prescribe for men of his profession all the usual intellectual disciplines, the experienced judge will still reserve a place in his opinions for philosophy and for consideration of social welfare.

He knows that among the issues which present themselves to his court, are great conflicting issues which belong peculiarly to his time and have not been met before. For many cases there are no exact parallels in the decisions of the past just because the social circumstances out of which the issues arise are new. New issues of that kind, if they are not disposed of, continue to plague the courts and continue to cumber the operations of the commonwealth until the law and the judgments under the law are finally obliged to recognize that new elements of public welfare are involved.

It will not do then for the high judicial officer to answer:

> "The law is the perfect embodiment
> Of everything that is excelent,
> And I, my lords, embody the law."

A Dred Scott decision will not be allowed to prevail though it be pronounced by a majority of the judges. The doctrine of citizenship set up by the Dred Scott decision had to be changed even at the cost of war and by amendment to the Constitution, because the public welfare demanded a change which would free the Negro and which would relieve our economic system, then being industrialized, of the incubus of slavery. In the long run, those who held property in men, millions of dollars in value, could not hope to prosper in a society where mechanical power was available to supplement mere man power.

If an issue presented to a court concerns only a simple, traditional property interest, then there are in the traditions and precedents of the law numerous and clear directives for the guidance of a judge.

If, for instance, the inquiry arises as to an owner's title to land, the references available to litigants and judges run deep into antiquity. The complex law of Land has volumes of history in which to found a decision.

But if the property rights involved in a private or public case are rights of a relatively recent origin which have arisen as a new thing in

* "The Nature of the Judicial Process," by Benjamin N. Cardozo.

the world along with the industrialization of our society, then the parallels of precedent are not so clear or do not exist. This is a large part of our predicament in considering the opposing claims of corporate ownership and unionized labor.

When we enter such new areas of legal conflict the issues are argued in the public press, in paid advertisements, in reports to stockholders, in pronouncements of labor leaders, in legislatures, and at home in heated conversations after dinner. The layman is called upon to make up his mind on the merits of the issue, even though he must say as did that distinguished layman of the '20s, Mr. Will Rogers, "All I know is what I read in the papers."

The pages of our papers have been packed with news, editorial proposals, and columnists' comments on a single subject, Strikes. We are made aware of the fact that behind these strikes lies a new and serious set of issues, affecting the public interest, not issues to be resolved by arbitrary dicta or by a routine recourse to precedents. The property rights involved in our present fracas are relatively new in the world. They date from the rationalization of industry, from the invention of the principles of mass production. The history of these rights, however crowded with events, is brief, too brief for our social purposes concerning them to have been embodied adequately in law.

The law of Land has thousands of years behind it, but the law of labor in the controlling environment of an industrialized civilization has run for decades only.

It was not until our fathers' times that all labor in this country was declared to be free and possessed of the rights of citizenship regardless of race, color or previous condition of servitude.

It is within our lifetimes that the universal application of mechanical power to the processes of manufacture has occurred. The great corporate structures responsible for the management of industrial production are younger than most of the people in this room. Some of the associations of workers organized to represent the interests of labor in collective bargaining have not yet, by the count of their years, attained the age at which an individual must accept full legal responsibility for his acts. No wonder that there is so much misunderstanding. No wonder that the language of justice is unclear and that the parties to the disputes lose their tempers even though their common interests are incomparably greater than their differences.

There is, I think, a parable of some value in the fact that we still speak in terms of "horse power" when we walk through a modern power plant. It is spotless, quiet, and almost unattended. The rooms have the dimensions of cathedrals, and the few workmen who are there attending to their guages and switchboards move about the place like priests mysteriously performing their rights. It should be almost a sacrilege to speak of horses or horse power there.

Of course, it is a trite thing to say that the machine has changed the entire organization of society. Our language and the terms of our laws unavoidably lag behind.

It may interest you for a moment to consider how greatly we have changed one institution fundamental in a democratic society, the institution of the schools.

Where does this great system of schools come from which we now enjoy?

At the time of the Philadelphia Centennial there were not more than 70,000 students in all the high schools of the country. Today there are 7,000,000. I talked recently with a man who said that in his boyhood there was not a single public high school in his state. In 1892 there was just one public high school on the island of Manhattan. Even in 1910 not more than 10 per cent of the young people of high school age were in school; by 1936 the proportion had risen to 36 per cent.

The transformations in higher education have been comparable. Today two or three metropolitan universities in one city graduate with Bachelors' degrees as many seniors as were given their diplomas by all the colleges of the entire country 40 years ago.

Economic forces have been at work which have radically changed the pattern of our life, forces which left their imprint nowhere more clearly than on our system of schools and colleges. The organization and the processes of American industry were suddenly changed in this period, while mechanical horse power replaced handpower and the machines released men from the factory. The first to be released were the children and the young people.

I do not know what economists say, but I think it must be true that most of the surplus labor, laid off from the factories, has been absorbed in the schools. The surplus time made by the rationalization of industry, and by labor-saving devices, and by mass production has been allocated to the younger generation. This is one of the many concealed and often forgotten profits of our modern kind of industry. It is a reserve of money and man hours laid aside for the development of our best national resources, the abilities of our young people.

What the worker finds in his pay envelope is not his only return on his labor. In a thousand ways his prosperity, his capacity to care for his children, to given them education and the conditions of healthful living depend on the successful, uninterrupted operation of the industrial machine. I am not suggesting that he owes his happiness to the beneficence of management, but that his prosperity is an inseparable part of the total prosperity.

A little while ago the owner of a coal mine in Western Pennsylvania and the men he employed were expected to settle their difficulties on their own. They could maintain with some reasonableness that it lay strictly within their own province to determine for what wages coal

could be taken from their small mining property, when it would be taken, and when the mine would be closed, either because the miners were not satisfied with their earnings, or because the owner was not satisfied with the profits he could get. Even if their disagreements were carried to extremes, this was still a private fight. It was cruel sometimes and destructive, but it was local, and no great significance was attached to it outside the immediate community of the mine. Neither the Government far off in Washington nor the public nearer at hand was considered to have any right to interfere.

But nowadays the industrial power and likewise the power of organized labor have been so magnified and at the same time so concentrated in relatively few hands, that the damage done by a strike reaches everywhere and soon offsets our general prosperity.

The immediate costs of the strike, to the corporation and to its employees, are disconcertingly great. The industries dependent on the products of a closed plant are hardly less inconvenienced than the striking concern itself. The general productivity of the country slackens. We then come to crises where some public action is required. Much as public interference is resented by both management and union leadership, reluctant as we are to modify the bargaining prerogatives of both parties, we are almost certainly obliged to conclude that public welfare requires some interference by Government.

As to the cost of strikes, we have abundant testimony:

1. The United States Steel Corporation in its latest annual report estimates that the steel workers themselves lost something like $207 each in straight-time wages during the recent four-week strike, and that it will take the worker two years and ten months to recoup his loss out of the increased rates won by the strike.

In production, the steel strike, with all the delays necessary before the companies could be returned to full operation, is reported to have cost the country nearly 3,000,000 tons of steel ingots.

2. The Westinghouse strike in three months is reported to have cost a loss in wages of $42,000,000 and a loss of business of $100,000,000.

3. These strikes, great as they were, seem insignificant affairs when we consider the damages done in every line of activity by the strike of 400,000 members of the United Mine Workers, A. F. of L. The losses pile up in daily reports. They were forecast and summarized in the President's report from the Office of War Mobilization and Reconversion which you read in the newspapers ten days ago. The quotation of a few phrases from that report will serve to show how deep and how wide is the destruction of a single strike:

Railroads.—On May 1st the country's class 1 railroads had an average of less than four weeks' supply of coal, and five of these companies are desperately short with nine days' supply or less.

Utilities.—Industries throughout the Northern Indiana area were asked to cut their electric current consumption to an aggregate of 24 hours each week.

Food.—The situation was reported to be "alarming" . . . in the dairy industry, among plants packing perishable food and in the processing and packaging of poultry and other perishable foods for domestic consumption and for export to the starving peoples of Europe.

Chemicals.—The loss of 50 per cent in plastic raw materials threatened and a serious setback in the fertilizer program.

Steel.—Unless the coal strike could be settled by May 20th, it was said that steel production would drop to almost negligible proportions. . . . Beyond May 15th tin mill production which is urgently needed to preserve the food pack would have to be curtailed.

Building Materials.—Plants manufacturing building materials . . . are now suffering.

Cotton.—It was forecast that fifty per cent of the cotton mills in the country will be completely shut down.

And all this just at the moment when every condition of civilization in the world is crying for full and uninterrupted industrial production! All this in the one country that has the greatest capacity for industrial production and that prides itself most on its equipment and its ability to manufacture!

We are all of us tempted to lose our tempers and to denounce somebody. Whom we denounce depends on the partiality of our views. The owners and managers, their representative associations such as the National Association of Manufacturers, the Government in Washington with its Labor and Mediation Boards, the unions and the workers themselves, all come in for a share in the curses. Some would pluck out certain eyebrows. Some would consider this to be the opportune moment to squash for good the extended labor power. Others see in an emergency like this the cue for a national scheme of Government ownership.

Whatever the outcome of the present conflict, whether we move to the right or to the left, the strikes we have endured this winter are enough to show us that there are still lacking the precedents, the instruments, and the procedural facilities to prevent crippling disorders in our industrial and economic affairs.

In our private affairs and in our altercations over money and property matters we have other means than fisticuffs and duels for the settlement of violent disagreements with the complete sanction of law. In our industrial affairs the means still are lacking.

The universality and the bitterness of our present day industrial conflicts will not be cured until we can consider the basic causes of them. They are not to be stopped by any superficial treatment of the symptoms—not by injunctions or by polite pleas for peace once the picket

lines have formed; not by an arbitrary, statutory outlawry of strikes; not by soldiers carrying managers out of the plants, nor by men in uniform put into the plants, to force men to work or to attempt to do the work. Neither arbitrary military authority nor mere benevolent politeness will effect a cure.

The physician must rely on something better than a show of official authority or a pleasant bedside manner. He will have to find out what is the cause of the trouble.

Likewise, those appointed to administer justice must have a knowledge of symptomatic facts and an acquaintance with prescriptions more effective than the emetics, elixirs, and pills of yesterday.

What has been said here by previous lecturers under the Day Foundation seems to me to be not unlike what I am saying now: that adjustments in our social organization must be made commensurate with the advances in technology, and that it is up to the layman in public affairs, including particularly the more skilled in the modern professions of production, to try to fit our habits of justice to the forms of modern industry.

In that tailoring process a reconsideration of some of the basic concepts of property may be involved. What is it that the industrial worker owns?

Perhaps an answer is suggested by a comparison between the Homestead Act of 1862 and the modern G. I. Bill of Rights. Eighty years ago the ambitious young fellow anxious to make his way was told, "Vote yourself a farm." The public domain was opened to him. Any able and willing youngster could have 160 acres of land from the Government. But in 1946 we say to him, "Get yourself training for a trade or for a job or for a profession. Invest in a skill. Invest your time and whatever credits the Government allows you because of war service in education for a job."

In an agricultural time the common man's reserve or capital was apt to be tied up in the ownership of land or in his right to the use of land. His rights and obligations as the owner of land were well defined under the law and were protected by hundreds of years of legal history.

In an industrialized civilization, however, the common man's capital is apt to be invested in his skill. The land on which he works, the plant in which he works, and the instruments and machines with which he works do not belong to him. He has no lease on them other than the contract which he and his fellow workers make with owners and managers in a collective bargain. His capital is, therefore, tied up in that contract, and the preservation of his capital depends on the validity of the contract.

Already we have gone a long way in the invention of courts to meet the special requirements of modern technology and to solve the special

problems, some of them of a legal kind, which are caused by a modern organization of industry on the grand scale of our corporations and unions of today.

For a long time we have been using boards of arbitration, privately appointed, whose decisions are accepted in advance by the parties to the disputes.

Even within the regular system of courts judges have resorted with increasing frequency to some fact-finding agency for reliable statements of factitive conditions. Justice Cardozo in his "Growth of the Law" calls this modern custom of judges "an impressive lesson in the capacity of the law to refresh itself from extrinsic sources and thus vitalize its growth."

Especially in what is now commonly called Administrative Law has there been an evolution of specialized judicial functions which lie somewhere between the executive and the commonly accepted judicial functions of the commonwealth.

An analogy may be drawn from the conditions under which the courts of Chancery arose in England. As I understand it, there was displayed in England at the end of the Middle Ages a need for some vigorous supplement to the traditional formalized courts of justice. Although there already existed courts for all the ordinary civil and criminal causes, there were other areas not covered completely. In the great and disturbing change from a feudal society in the direction of a modern nationalized society, the courts moved slowly. So the sovereign, through the chief law member of his council, undertook to break through the meshes of tardy procedures and to redress wrongs which were unrighted by juries. Extraordinary justice was to be administered by the Chancellor. His function, though jealously watched, was received with approval in decisions affecting trusts, and wherever it might be said that the conscience of the king, or the public welfare of the kingdom was touched. He was not supposed to be tightly bound by precedent. Adaptability was of the essence of the kind of justice to be rendered in the courts of Chancery. The result was a refreshment of the law of England and additions to the precedents in equity over centuries.

Our experience with extra-legal mediation boards in recent years seems to indicate that by trial and error, and by common everyday judgment, we may now be devising the extraordinary courts made necessary by our recent shifts from an agricultural to an industrialized way of life. The evolution may lead sometime to a more formal establishment of courts of industry or courts of labor.

But in addition to our own experience in instituting extraordinary tribunals, we can observe the experience of other nations. These may not have established precedents for us, but they suggest parallels. Of course, I do not refer to the misbegotten and destructive experiments of

the totalitarian states where arbitrary controls were set up over industry to produce a new order, and where instead was delivered a new and more hideous disorder. Some of our best foreign examples—and they are examples, not models—are probably to be found in such free, enlightened, cautious and constitutional states as Sweden where a high state of industrialization has been attempted. In Sweden the processes of collective bargaining by institutionalized associtaions of capital and labor seem to have gained a quasi-governmental prestige without disturbing the principles of free enterprise. For some years Sweden has had Labor Courts which seem to work with a full authority to protect individual rights, corporate rights, and public rights in industrial disputes. As in the time of the establishment of the courts of Chancery in England, the competence of the new courts is restricted: when the common law offers a remedy the new court should not intervene.

It would be foolish for a layman to attempt to draw up specifications for courts of industry or courts of labor. The judicial structure is not built according to an office plan. It is more apt to be built as were the great cathedrals, built through centuries and by a succession of builder-architects on the job. My purpose is only to point to the need for such specialized courts. It is just to say that they are already being made, and to propose that the engineer, the technicians, and the expert on production, whose professional concerns are with the technical problems of production, may presently have a well defined and influential place in such courts.

Industrialized production is the peculiar function of the engineer. His primary professional interest is in the conditions favorable to production. It is for this reason that he is strategically placed in the industrial conflicts of the day. He goes into the plant to invent, design, install and operate machines. Any factor of friction unfavorable to production is a proper subject for his professional studies, any factor mechanical, economic, or psychological. He, more than any other person having a professional role in the business affairs characteristic of our industrialized civilization, may be expected to take an objective fact-finding part in the resolution of the economic crises of our time. It is for this reason that the technically trained man has advanced to a place of highest administrative responsibility in the management of great industries. Whether or not he chooses to accept social responsibilities too, he cannot escape them. It may have been a surprise to Frederick Winslow Taylor, the first noted advocate of what we call Scientific Management, to find his name in the headlines some thirty-five years ago when there came before the Interstate Commerce Commission a celebrated railway rate case; but his premises of industrial efficiency provided good grounds for a brief on the ability of railroads to pay increased wages without revising freight rates upward.

In the decisions affecting rates, returns, and wages which are always the immediate issues awaiting arbitration, there is a superior matter involved. That is the consideration of over-all industrial productivity. Our commonwealth, the prosperity of all of us, the prosperity of workers and owners alike, is dependent on increased and continuous industrial productivity. Unless the attention of mediators comes finally to that subject, so that both parties to the dispute accept its significance to all the persons they represent, there is little chance of just conclusions, amiable settlements and public approbation.

Puts Heat on Plywood.—A test that is really tough has been used for testing plywood that is glued with a new bonding compound developed at the Northern Regional Research Laboratory at Peoria, Ill. Plywood has long been used mainly for interior construction because it did not stand up under exposures to changes in moisture and temperature that are the rule in exposed construction. The glue would fail and the layers of thin wood veneer would separate.

Experimenting at Peoria, U. S. Department of Agriculture chemists were seeking uses for soybean meal that is left after extraction of the oil. They combined the meal with phenolic resin plastic materials and found that the soybean meal could be substituted for a third of the more expensive phenolic resins as a glue for plywood. Results looked promising, but the question was: Will the plywood stand up under exposure to rain and sun? It would take years to find out under conditions of practical outdoor exposure.

For a quicker answer, they used an accelerating weather chamber for testing panels of plywood. In this tester the glued plywood is sprayed with water for five minutes during each two hour period. For the remainder of the time the plywood is exposed to the glare of carbon arc lights that make the chamber "hotter than all outdoors"—120 to 140 degrees F. Tests run up to 750 hours, a full month, with 375 changes that are the equivalent of a driving rain and extra hot sunshine.

Results have indicated that the combination soybean and resin binders are durable in exposed construction. Used with birch veneer, glue in the panels has remained in good condition after a month of this super-weathering. Where the panels have failed it has been because conditions in the tester destroyed the wood, not the glue.

A hardwood plywood mill cooperated with the Peoria scientists in commercial tests of the new glues, and found results so satisfactory that it is now using soybean meal as an extender in all its phenolic resin gluing.

R. H. O.

A PREVIEW OF THE WESTERN UNION SYSTEM OF RADIO BEAM TELEGRAPHY.*

BY

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PART II.

The radio equipment has been developed by The Victor Division of the Radio Corporation of America, at Camden, N. J., with Western Union engineers cooperating during the past year of joint experiments by offering suggestions, by outlining requirements, in overall testing, and in providing suitable arrangements at the terminals, including carrier circuits, housing and power.

One of the most important decisions to be made in designing a radio relay system suitable for telegraphy is the choice of a modulation method. In the RCA equipment, frequency modulation has been selected, as this type of modulation meets the requirements of a broad-band system much better than amplitude modulation. However, in the Thompson system of frequency modulation, not only is the final radio frequency carrier frequency modulated, but a sub-carrier is employed, and this sub-carrier is also frequency modulated, as will be explained in the following paragraphs.

The final radio frequency carrier, located in the center of the assigned frequency band of the station, will be simultaneously frequency modulated by two groups of input signals. The first group is comprised of a 1-megacycle sub-carrier and its associated sidebands. The peak amplitude is adjusted so that a 2-megacycle deviation is produced in the output frequency. The 1-megacycle sub-carrier is frequency modulated by the output of the Western Union voice-band translation equipment and has an average deviation of 200 kilocycles, with an occasional peak deviation of 400 kilocycles. This group of input frequencies has been termed the signalling channel, and it is available only at the terminals of the system.

The method adopted for sub-dividing the signalling channel into usable voice bands is the same as the one employed for wire line operation, except that it is a much larger system, and supplies 32 voice bands, each 500 cycles to 3,100 cycles wide. This requires a frequency spectrum extending from 500 cycles to 150,000 cycles. As in the case of wire line operation, any one of the voice bands may be utilized as a

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telephone or facsimile circuit, or further sub-divided into the various types of telegraph carrier channels.

The second group of input signals corresponds to those frequencies comprising service modulation. Service modulation will consist of a telephone channel for technical conversations between terminals and the relay stations, or the telephone channel may be used to transmit certain test-tone frequencies which will be used to indicate conditions of operation and for a remote monitoring method. The peak amplitude of service modulation will produce a 100-kilocycle deviation of the final radio carrier. The service channel is available at all stations, and can be used without interference to the signalling channel.

The radio system has been designed to give a normal signal-to-noise ratio of 50 db. in each of the derived voice bands, consideration having been given to the possible employment of the various types of telegraph service in any combination. Actually, experimental results have been superior to the design value. In a frequency-modulated system, the signal-to-noise ratio depends upon such factors as the deviation, the band width of the receiver and its internal noise, and the amplitude of the signal at the receiver input, the latter being affected by the transmitter power, the net gain of the transmitting and receiving antennas including connections thereto, and the attenuation and fading characteristics of the propagation path. Experimental results on the New York-Philadelphia system indicate that the required signal-to-noise ratio can be obtained with a transmitter power of 50 milliwatts. The signalling channel is preemphasized, with corresponding correction applied at the receiver, to insure that the noise is equally divided between the derived voice bands.

The channel band width of the RCA system is of interest. When the frequency-modulated sub-carrier is applied to the final radio frequency carrier as a frequency modulation, the result is a number of upper and lower sidebands spaced 1 mc. apart, and a multitude of smaller sidebands which lie on either side of the principal sidebands. It is necessary to receive only the first and second order sideband groups on either side of the final carrier, the amplitude of the third and higher order sidebands being important only in considering adjacent channel interference. Therefore, a channel band width of 6 megacycles should be allowed for each transmitted carrier with its essential modulation to protect the adjacent channels, although only a four-megacycle receiver band width is required.

Two other factors must be considered, both relating to channel band width. One is the stability of the transmitter frequency, and the other is the accuracy of frequency measurement. A stability of 0.04 per cent. may be achieved by the use of a precision reference cavity and an automatic frequency control system applied to the oscillator tube. A heterodyne frequency meter with a cathode ray tube indicator will

serve to measure the frequency within 0.01 per cent. The following table shows a summation of the three factors upon which total transmission band width depends:

Frequency Band	Sideband Width	Stability	Accuracy	Total
2,000 Mc.	6 Mc.	1.6 Mc.	.4 Mc.	8 Mc.
4,000 Mc.	6 Mc.	3.2 Mc.	.8 Mc.	10 Mc.
6,000 Mc.	6 Mc.	4.8 Mc.	1.2 Mc.	12 Mc.
11,000 Mc.	6 Mc.	8.8 Mc.	2.2 Mc.	17 Mc.

Adequate receiver stability is achieved by a similar automatic frequency control system applied to the high-frequency oscillator, referencing to a standard cavity rather than the transmitted carrier.

As stated previously, only a few assigned frequency channels will serve a large area, because they can be used repeatedly. It is believed that 8 frequency groups will provide one radio beam telegraph system between each of the larger cities of the United States. As to which frequency band will be the most dependable, the results of further experiments must be awaited.

It was anticipated that in a microwave system, the received signal would be subject to certain variations. At a wavelength of less than 1 cm., the frequency is high enough for molecular phenomena to be an influence. Selective absorption of energy by the oxygen and water vapor in the atmosphere produces an attenuation, but at a wavelength longer than 1 cm., this is a minor effect, the average attenuation being in the order of 0.05 db. per mile. During a rainstorm, there is another type of absorption, depending upon the wavelength of operation and the density of rainfall, but this effect, for a wavelength greater than 5 cm., is not very serious. Furthermore, a heavy rain usually occurs over a distance of only a few miles at one time. At 1 cm., a heavy rainfall can produce an attenuation as high as 35 db. per mile.

Experimental verification of the presence of signal variations due to the above effects has been obtained, but it must be remembered that in an FM receiver, an amplitude limiting system is employed. Therefore, an input variation in the order of 10 db. is of no importance, if the minimum signal is sufficient to provide the necessary signal-to-noise ratio. It is only necessary to provide enough power to overcome the space loss, plus these added attenuations due to the characteristics of the medium.

It was also experimentally determined that the interposition of an airplane in the path of the beam causes no harmful effect, unless the craft comes within 100 feet of the station and directly in front of an antenna.

In the latter part of June, 1945, a much more serious effect was first observed. On a still night, between the hours of midnight and dawn, and especially during periods of high humidity, signal fading became severe. Increased transmitter power was found ineffective in keeping

the signal above the minimum required value. It was soon discovered that the receiving antenna was located in a local field of complex nature, and that the signal in another antenna placed about 50 feet lower than the first would be strong when the signal in the higher antenna was weak. Therefore, vertical diversity reception was indicated, and will be employed on the next equipment installed, thus limiting total fading to approximately 15 db. per section.

The deep fading reported above is believed to be the result of multi-path transmission. Some of the energy which leaves the transmitting antenna at a slightly higher angle than the directly propagated ray appears to be refracted and follows a curve of shorter radius due to an abnormal change in the index of refraction with altitude. This energy reaches the receiving antenna under conditions that the path length is an odd multiple of a half wavelength longer than the directly propagated path, which produces a weak field at that particular point.

There is another school of thought on this subject. It has been reported that radar sets pick up spurious echoes. These echoes occur most frequently over water, or from shore to sea, and moving storms have been tracked. It has been thought that such reflections were probably a matter of sharply bounded layers of discontinuity in the atmosphere, such as two layers of air of different temperatures or charged bodies of air, but it is doubted if clouds or aerial vortices could produce such effects. It might be possible, therefore, that the abnormal ray, which causes the deep fading by the mechanism of phase cancellation, is a bundle of reflected waves, and that some phenomenon, such as temperature inversion, is responsible. Whatever the cause, diversity reception, or extremely sharp directivity in antennas, are the indicated remedies.

Another matter which received a great amount of attention was the distortion produced in the overall system. It is obvious that to span the United States would require almost 300 repeaters. If the distortion products of each receiver and each transmitter of an ordinary frequency-modulated system were to be cumulated, the derived voice bands would be overloaded with cross modulation, an intolerable condition. In the RCA system employing double frequency modulation, much of the distortion of a conventional frequency-modulated system is eliminated.

At the terminal receiver, two intermediate frequency amplifiers are employed, both with limiters and discriminators. The 1-megacycle sub-carrier is re-established at the output of the first amplifier-discriminator combination, fed into the second, limited, detected, and after amplification is connected to the voice-band translation equipment. Thus, in the terminal equipments, distortion is held to a very low value.

At the repeater stations, a different method is followed. Only one intermediate frequency amplifier is employed. The output of this

amplifier-discriminator combination is, of course, the 1-megacycle sub-carrier, and this sub-carrier is connected to the input of the forwarding transmitter directly, instead of being demodulated. The measured overall distortion of such a repeater is extremely low. Until the factory-produced equipment is installed and tested the exact distortion values will not be available, but it is believed that the overall distortion on a 300-mile system can be held to less than a tenth of one per cent.

In making use of the input spectrum of the radio system (150,000 cycles), it is first necessary to derive voice bands. As previously mentioned, existing G System translation equipment will be used in the initial installations. As soon as the newly-designed WN-1 translation system equipment is available, 32 voice bands will be available.

Figure 10 is a chart which has been prepared to show the arrangement of tuners and modulators employed in the WN-1 system to translate the 32 voice bands to appropriate positions in the spectrum. A similar arrangement must be used on the receiving end to unscramble them. This is known as a WN-1 Carrier System. It uses existing G System equipment for the first eight voice bands. Later on, these will be replaced by equipment of newer design, at which time, the system will be called a WN-2 system.

Each voice band may be sub-divided into telegraph channels in the same manner as with a wire system. (See Fig. 7.)

The layout of the repeater sections presents an interesting problem. An examination of the capabilities of the radio equipment shows that with presently available tubes, a maximum repeater separation of approximately 55 miles is feasible. It is obvious that the topography of the land will have a most important bearing. Towers of different heights may be employed. And a good repeater location will be near a heavy commercial power line and accessible from well-traveled roads. But an examination of the propagation characteristics of these micro-waves introduces an additional requirement, electrical in nature; namely that sufficient terrain clearance must be provided to insure the equivalent of free space propagation along the path between the antennas. This means that the selected elevations must be high enough to clear the earth's surface and any obstructions which might cast a shadow, and also sufficient to prevent any energy reflected from the earth's surface from cancelling the directly propagated energy. This can be done if an additional clearance ranging from 30 to 50 feet is provided. Furthermore, this additional clearance must not be too great, especially over water. It must be just right for the particular condition of operation. Following these principles, the repeater or relay stations for the New York-Philadelphia system were initially located at Ten Mile Run, just south of New Brunswick, N. J., and Bordentown, N. J. Recently it has been found that there was an obstruction in the New York to Ten

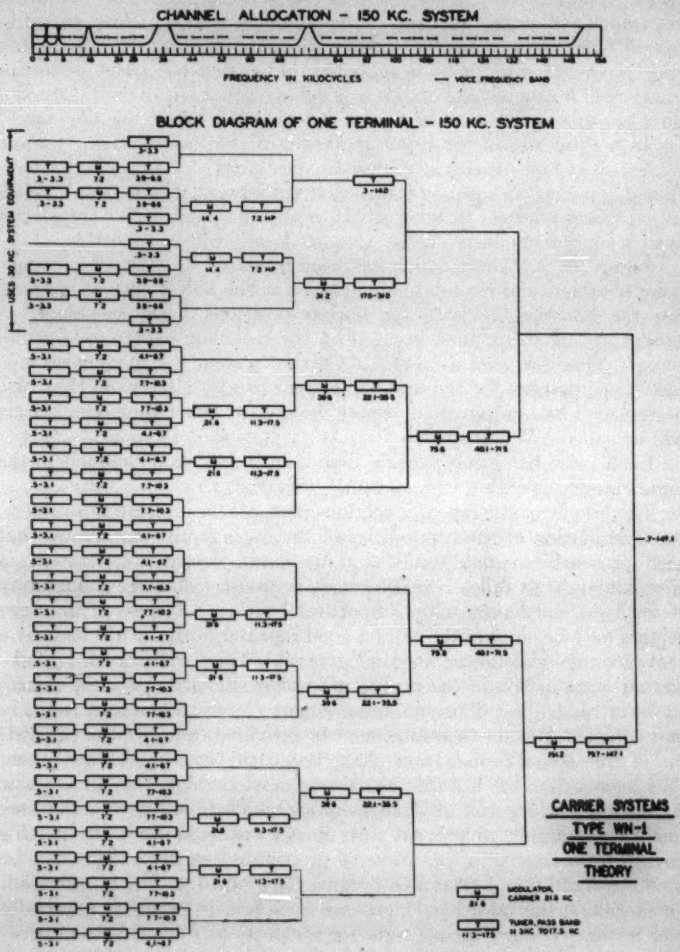

FIG. 10. WN-1 Carrier System.

Mile Run section, and it will be necessary to add a third relay station at Woodbridge, N. J.

Figure 11 is a photograph of the New York Western Union Building. It is 24 stories high, and the elevation of the roof is about 400 feet above sea level. On the roof of the penthouse may be seen the two antennas of the New York to Philadelphia circuit.

Figure 12 is a photograph of the antennas on the roof of the New York building. The radiating element of one antenna and the receiving element of the other are housed in plastic covers on the projecting end of the coaxial feed line. A metal plate reflects the energy which

FIG. 11. The New York Western Union Building.

would ordinarily be radiated in the forward direction backward toward the parabolic surface of the large reflector. These antennas have a power gain of approximately 18 db. and a beam width, at the half power point, of 6 degrees. Mr. H. P. Corwith, the Assistant Chief Engineer, is shown standing beside one antenna.

Figure 13 is a terrain profile of the New York to Woodbridge, N. J., circuit path. In making one of these charts, the distance between stations is laid out as the abscissa, and an appropriate altitude scale is selected for the ordinate. The actual curvature of the earth is then drawn, which of course will be a different radius curve for each distance,

and altitude scale. The elevation of the ground above sea level is then transferred to the profile from a contour map, such as a U. S. Geodetic Survey Map. Finally, the tower or building elevations at the terminals

FIG. 12.

are superimposed. A straight line connecting the points where the antennas are located indicates the path taken by the radio beam. A large amount of work is involved in preparing trial profiles, and arrang-

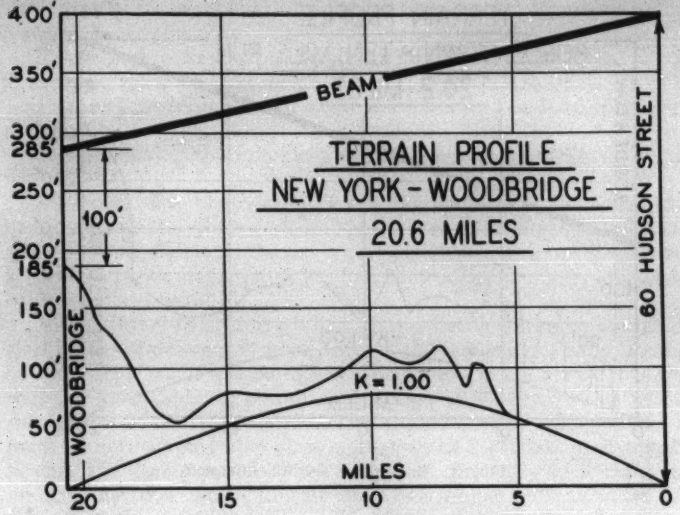

FIG. 13. New York-Woodbridge profile.

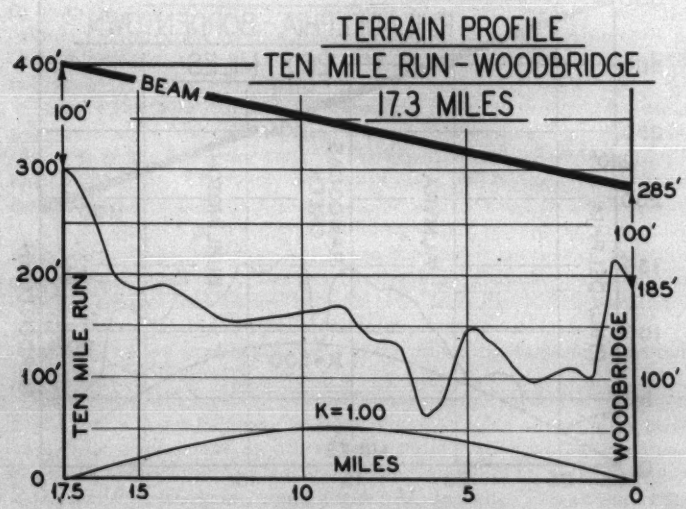

FIG. 14. Ten Mile Run-Woodbridge profile.

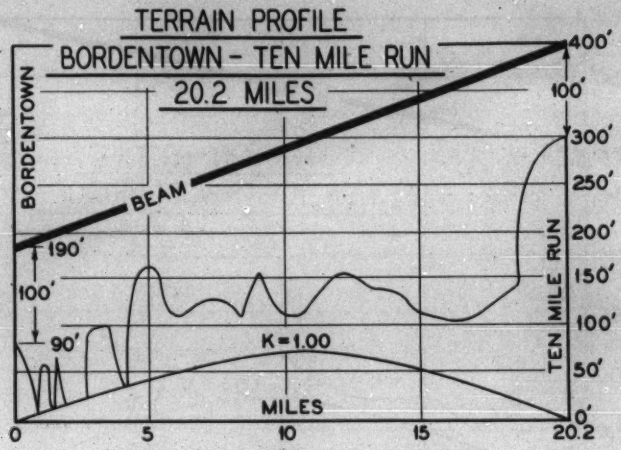

FIG. 15. Bordentown-Ten Mile Run profile.

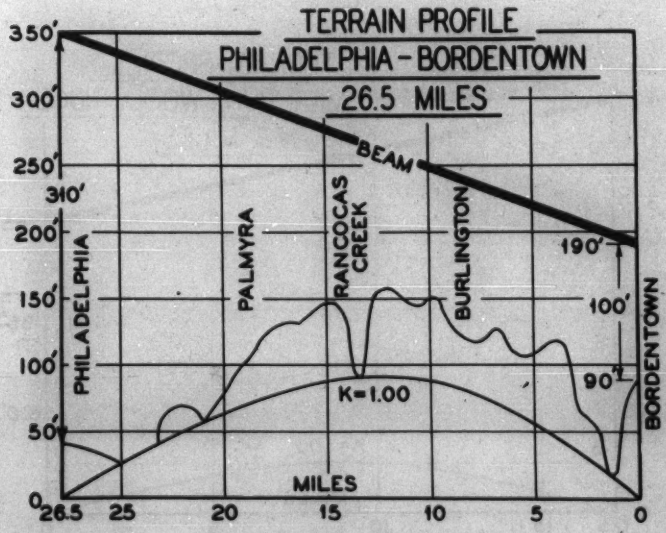

FIG. 16. Philadelphia-Bordentown profile.

ing for the purchase of land sites for repeaters, especially where zoning restrictions are effective.

Figure 14 is a terrain profile of Ten Mile Run-Woodbridge circuit path.

Figure 15 is a terrain profile of the Bordentown-Ten Mile Run circuit path.

Figure 16 is a terrain profile of the Philadelphia-Bordentown circuit path.

Figure 17 is a photograph of the Bordentown radio beam relay tower, a part of the New York-Philadelphia experimental system. The ground plane antenna on the top is not part of the beam equipment, but is part of a police radio system used for communication before the beam equipment was installed.

In the interests of universality, it was decided to standardize on steel towers of different heights, all with the same size apparatus cabin on top. This cabin will be 12 feet square, and 9 feet high. The side walls are removable, to permit substitution of windows which will be transparent to the radio waves. The windows, which will probably be made of impregnated fibre-glass cloth, will be protected mechanically against the accumulation of ice and snow, probably with the automatic application of heat to melt off any accumulation that forms. In this connection, it has been found that ice does little harm, but wet snow produces a large reduction in signal strength. The cabin is large enough to accommodate the four antennas and four high frequency oscillator cabinets required for each of two complete radio relay equipments, although initially, only one circuit will be repeatered at many of the towers.

Figure 18 is a sketch of the tower which has been designed for use at relay stations. The cabin is large enough to contain the antennas, and the steel is much heavier than in the experimental tower, resulting in better stability. The newly-designed towers will be used on the future installations.

At the base of each tower, a building about 16 feet by 30 feet will be erected. This building will house the major portion of the radio equipment, which is connected to the high frequency cabinets by coaxial, control and power cables. The building will be heated in winter and ventilated in summer to insure dryness.

Figure 19 is a working drawing of the apparatus building to be built at the base of each relay tower.

The apparatus building will also house emergency power equipment. Some means must be provided for having available an unfailing power supply for a relay station, otherwise, a radio system would be no more dependable than the power lines which serve it. The radio equipment operates from 60 cycles, single phase, AC power. This power is supplied through a voltage regulator of the saturated-iron type. If the

line voltage input to the regulator drops below the control point, even momentarily, the radio equipment will be instantaneously transferred to a storage battery-inverter combination. At this time, a gasoline

FIG. 17. Bordentown tower.

engine-driven alternator set is started up, and when the machine is running perfectly, the radio equipment is transferred to the AC output. A time delay mechanism will be used to transfer the radio equipment

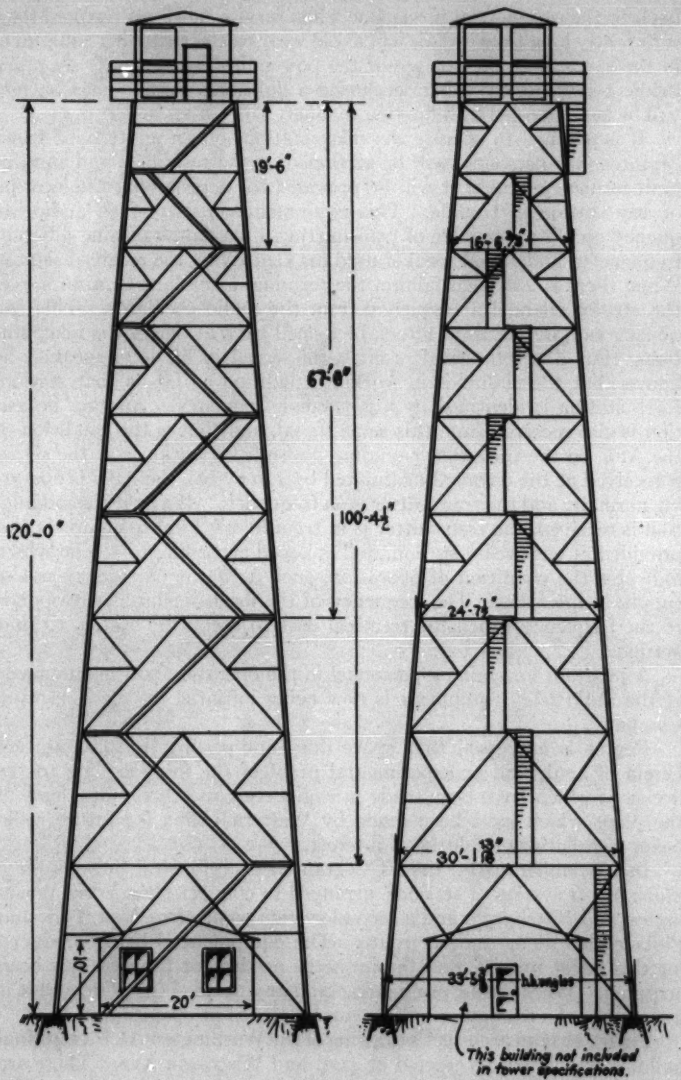

FIG. 18. Western Union tower.

back to the commercial power line when service has been restored for a sufficiently long time. This will avoid wear on the switching equipment in the event that the voltage of the power line is constantly dropping below a satisfactory value, as during a lightning storm. The battery will be kept charged by a floating rectifier.

It is planned to operate the relay stations on an unattended basis. Maintenance personnel will be stationed at the terminals and suitable fault locating equipment will be provided for determining the location of any station in trouble. This equipment consists of an audio-frequency oscillator, capable of transmitting a maximum of nine different frequencies, and a loud speaker used for identifying the received signals. When there is a system failure, the terminal attendant transmits over the service channel a frequency from the audio oscillator. This frequency will, by means of filters, be looped back at one of the relay stations, thus if the terminal receives the signal in his loud speaker, he knows that the circuit is in working condition as far as that station. Each station is identified by a particular frequency. Another indication is also received from this same signal, and that is the condition of the AFC on the transmitter sending beyond the station. If the signal is received at the terminal modulated by 120 cycles, the AFC is operating normally and the transmitter is on frequency. If a 60-cycle modulation is received, the transmitter is in trouble. A local oscillator is also provided at each relay station, and is keyed according to a code which indicates the condition of operation, such as if the emergency power supply is operating. The frequency of the local oscillator corresponds to the frequency which the treminal uses to check the system to that station.

A program for training personnel in the operation and maintenance of the radio relay equipment is now being initiated by the Telegraph Company.

Regret is expressed that space does not permit the presentation herein of analytical or experimental proof of the facts leading to the decisions which have been made in engineering matters. But some of the plans which have been made by Western Union for future radio beam installations might be of interest.

In November, 1945, the FCC granted experimental licenses for a much larger system of stations, arranged to connect New York, Washington and Pittsburgh, and a second system connecting New York and Philadelphia along another route. The equipment is being produced for this latest project, and the property needed for the sites has been acquired. Work is now progressing on many parts of the plan, and it is hoped that the triangular system can be placed in operation in 1946.

Figure 20 is an architect's drawing of the Washington, D. C., terminal building which will be erected at 41st. and Wisconsin Ave. There are three possible ways of arranging a radio beam terminal station. The

Washington arrangement is one of these. The new building will contain not only the radio equipment, but also the voice-band translation equipment. The Western Union main office, about six miles away,

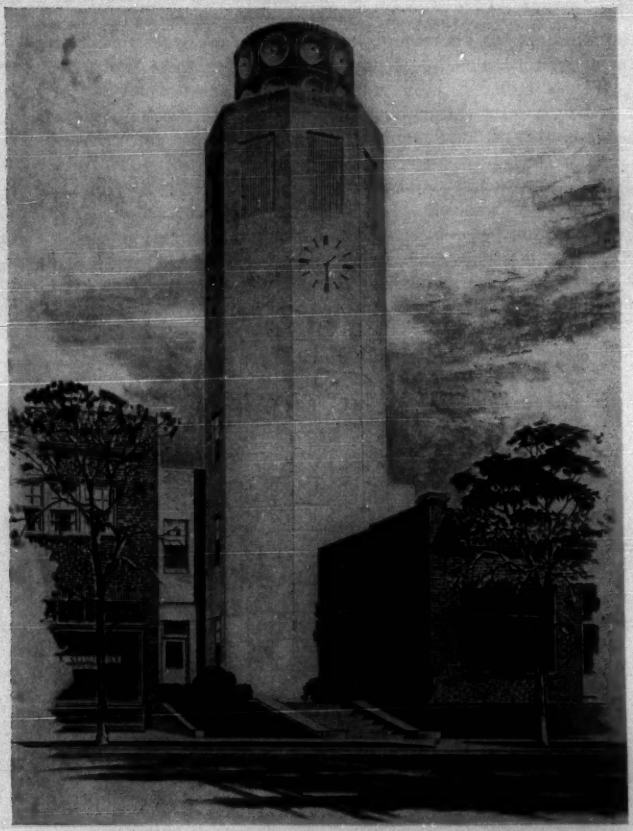

FIG. 20. Washington, D. C. radio beam terminal.

will contain the telegraph channel terminals, and lead-covered cables will be used to conduct the voice bands between the two buildings.

At Philadelphia, the radio equipment will be located in the penthouse of the Market Street National Bank Building, but the voice-band

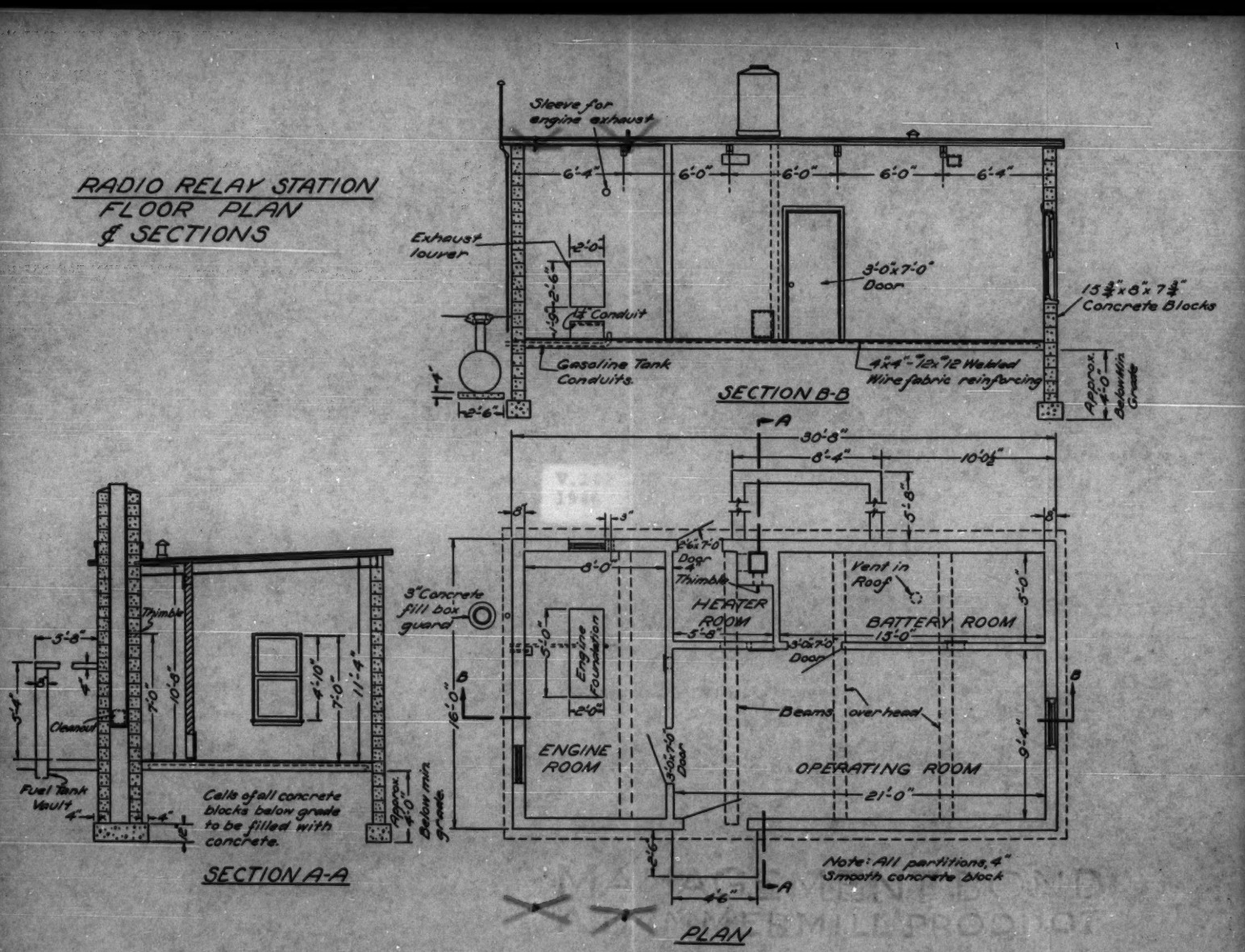

FIG. 19. Western Union apparatus building.

translation equipment and the telegraph channel terminals will be located in the Western Union main office, about a mile away. In this type of installation, coaxial cables will connect the two locations, and these cables will carry the entire signalling channel, 500 cycles to 150,000 cycles.

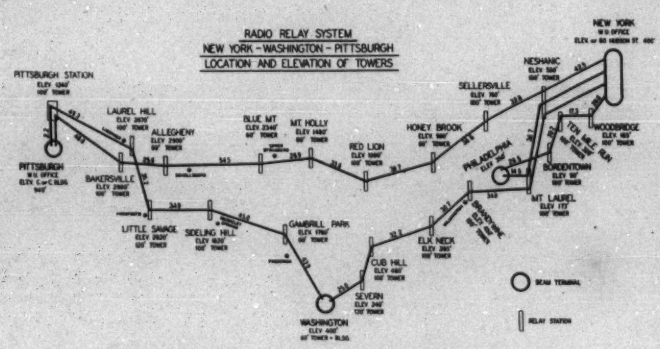

FIG. 21. Layout of New York-Washington-Pittsburgh system.

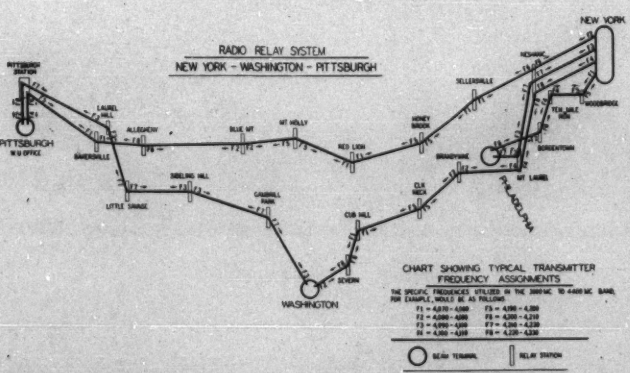

FIG. 22. Typical transmitter frequency assignments.

At Pittsburgh, and New York, all of the equipment will be located at the Western Union main offices, but in the case of the Pittsburgh installation, a very short radio relay link, only 3 miles long, will be employed as the last section.

Figure 21 is a drawing showing the layout for the New York-Washington-Pittsburgh system. The figures on each section indicate

the distance in miles between stations. The elevation of the ground and the tower heights at each station are also shown.

Figure 22 is a chart showing typical transmitter frequency assignments in one band. It shows how eight radio channels can be employed to give extended coverage.

Extensions of Western Union's radio operations are planned generally in the form of triangular relay systems which eventually will interconnect all major cities in the United States. The next system projected for installation will connect Chicago and Pottsburgh via two routes, one through Columbus and Cincinnati and the other through Cleveland and Toledo, thus establishing the second major triangle.

Figure 23 is a map showing the trunk circuits of the radio beam type which are planned to be in operation in 1949, the last year of Western Union's post-war facilities improvement plan.

From the terminals, cities and towns in transmission areas will be reached over existing wire lines. Radio transmission gradually will replace an extensive mileage of existing telegraph pole lines and the

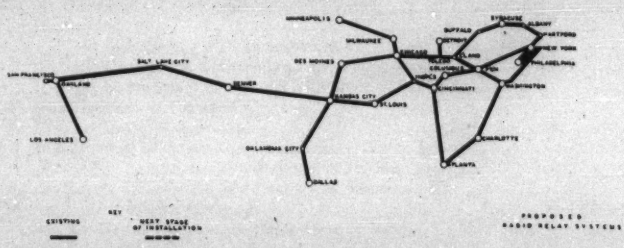

FIG. 23. Proposed radio relay systems.

wires which they carry. This will save the present heavy costs of maintaining and replacing this pole and wire plant. Removal of pole lines requires government approval, and cannot occur, in any event, until radio operation has become established and existing contracts permit.

In any new development there are by-products which become valuable. So it is with radio beam telegraphy. The application of this new method of transmission is not likely to be restricted to trunk systems, but will find much use in short-distance systems, as between a large city and its suburbs. For this service, some of the higher frequencies hold great promise. Another field of application is for railway communications. Television relaying and communications with airplanes, or other moving craft, have already been mentioned. An example of this latter type of telegraph transmission, in which there is great interest at the present time, is the local delivery of telegrams. By placing a transmitter in the Western Union's main

office, and a receiver in a delivery vehicle, continuous contact can be maintained, which will speed up the delivery of the message and avoid much unnecessary driving. Another most interesting field of application of microwaves is for burglar alarm systems.

Finally, I wish to acknowledge the many helpful suggestions and technical assistance received from many sources, including not only my co-workers in the Western Union organization, but those in the Radio Corporation of America.

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SECONDARY ELECTRON EMISSION FROM OXIDE-COATED CATHODES.*

BY

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PART II.

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IV. EXPERIMENTAL DETAILS AND RESULTS: PULSED EXPERIMENTS.

A. Initial Search for Time Effects.

1. *General Discussion*

Various individuals had proposed that the high secondary-electron yields observed in this Laboratory are possibly attributable to the Malter effect or some modification thereof. The necessity for invoking any such mechanism was not immediately apparent, however, and the explanation did not appear to be in accord with certain theoretical and experimental facts. It seemed desirable to obtain additional experimental evidence pertaining to this matter, and a search for time effects provided the most direct approach to the problem.

Thin-film field emission was originally observed by L. Malter [6] using an electrolytically-oxidized aluminum surface treated in a special

* This work was done in whole under Contract No OEMsr-358 between The Franklin Institute of the State of Pennsylvania and the Office of Scientific Research and Development, which assumes no responsibility for the accuracy of the statements contained herein.

manner with caesium and oxygen (Al − Al_2O_3 − Cs). True secondary emission from the surface results in the establishment of positive charge on the surface, and a polarization of the oxide film. This positive charge, acting through the thin oxide film, produces a high gradient resulting in the emission of electrons through the surface. The removal of the primary beam does not result in the immediate cessation of the field emission, but rather in a slow decay which is due to the fact that the surface charge takes an appreciable time to leak away. Similar time lags are noticed when the beam is first applied.

In the case of Malter's special films, the electron currents which flowed to the positive collector were sometimes several thousand times as great as the primary current. Furthermore, secondary currents persisted for hundreds of seconds, hundreds of minutes, and even longer after the cessation of the bombarding primary beam. Illumination of the surface reduced both the high yield and the decay period, due to the decrease in the effective resistance as a consequence of photo-conductivity.

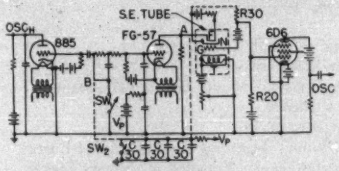

FIG. 11. Circuit utilized in the initial search for short time changes in secondary electron emission.

A fundamental argument against invoking the Malter effect for explaining the yield from oxide-coated cathodes involves the temperature-dependence of the electrical conductivity of these surfaces. Various investigators [11] have shown that the resistivity of BaO + SrO cathode coating *decreases* with temperature. The previously mentioned illumination effect indicated that a decrease in resistivity *reduces* the Malter effect, whereas it is observed that the secondary electron yield from an oxide-coated cathode *increases* as the temperature is elevated.

2. *Experimental Procedure*

With certain modifications, the apparatus developed by W. E. Ramsey [12] for studies of the decay of thermionic emission was utilized in the search for time effects of secondary emission. Fig. 11 is a diagram of the essential circuits.

Two types of experiments were performed. One was designed to reveal the possible existence of a change of secondary emission with

time following the application of the bombarding beam, while the other was intended to indicate whether the secondary emission persists and decays after the interruption of the bombarding primary electron beam.

In the former case, the cycle is initiated by closing the mercury switch SW_1. This immediately causes a positive pulse to be impressed upon the grid of the 885, thus starting the horizontal sweep of the oscillograph. Simultaneously the grid of the FG 57 grows more positive in potential at a rate determined by the associated time constants and voltages. The tube can therefore be caused to strike at any time after the initiation of the sweep. The electron gun of the S.E. tube is connected directly to the plate of the FG 57. This thyratron has sufficiently low impedance, when conducting to bring its plate to very near its cathode potential, thereby putting up to 1,000 volts on the electron gun. The secondary electron current from the target cathode T to the positive collector grid G is measured by impressing the voltage drop across R_{20} upon the vertical plates of the oscillograph through a single stage of amplification (6D6).

In the second experiment, the circuit components lying between A and B on Fig. 11 are disconnected, and replaced by the dotted line connections. The switch SW_2 shorts out the condensers C_{30}, thereby interrupting the primary electron accelerating potential. The pulse also triggers the thyratron starting the oscillograph sweep.

To test the operation of the circuit, an artificial decay was introduced. This was accomplished by disconnecting the electron gun filament supply, and inserting the resistor R_{30} having a value such that the current through R_{20} was the same as that normally due to secondary electrons. Various condensers placed across R_{20} produced different artificial decay periods. These tests revealed that it was possible to observe the effect of a time constant as low as 10^{-4} sec.

3. *Results and Conclusions*

Each of the two types of experiments yielded negative results. There was no evidence of growth or decay of the secondary electron emission following application of the primary electron beam, nor was there any indication of persistence and decay of secondary electron emission following interruption of the primary beam. This should constitute a sensitive criterion for the non-existence of the Malter effect for oxide-coated cathodes.

B. Studies With Microsecond Pulses.

1. *General Remarks*

Experiments performed by J. B. Johnson [13] yielded results which he has ascribed to a new type of electron-emission from oxide-coated thermionic cathodes. This phenomenon manifested itself as an elec-

tron current from the target gradually increasing microseconds after the onset of primary bombardment, and a more slowly decreasing current persisting after the abrupt cessation of the bombardment. The effect was described by Johnson as "enhanced thermionic emission excited by electron bombardment." It presumably varied with temperature in about the same way as the steady emission, thus roughly following Richardson's Law. It increased with bombardment voltage and current density, and might exceed the steady thermionic current in value. Calculations reveal that the surface temperature rise of the target caused by the bombardment is far too small to explain the increased emission. It was asserted that the effect no doubt explains the exponential rise with temperature previously reported for the yield from

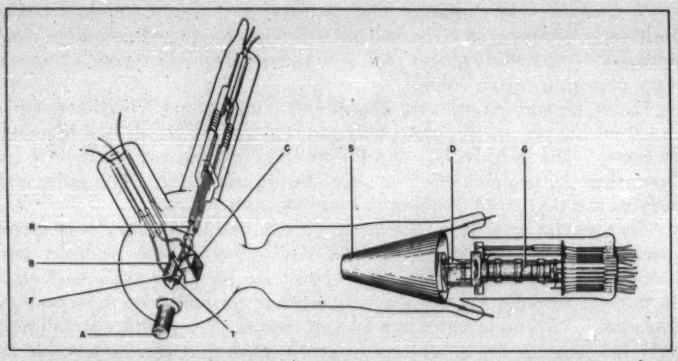

FIG. 12. Special S.E. tube used in experiments on pulsed and steady secondary electron emission. *G* is the electron gun and *D* the deflecting plates for altering the position of the beam. *S* is a shield electrode. *C* represents the collector and *T* the target cathode which can be slid from the indicated position into the Kovar anode *A* for diode measurements. *B* is the guard electrode with an adjacent tungsten filament *F*.

oxide-coated cathodes. Johnson concludes from his data that when he subtracts "enhanced thermionic emission" from the total electron current, the secondary emission does not increase with temperature.

The practical importance of ascertaining the magnitude of the secondary emission available in microsecond pulses, as well as the significant theoretical implications of the results of Johnson, stimulated an attempt to obtain measurements in the 10^{-6} sec. range. However such observations were not feasible with S.E. tubes as a consequence of interelectrode capacitance effects which predominate short-time measurements. A new type of experimental tube, embodying the desirable features of the S.E. tubes, was therefore designed for these experiments.

2. Description of Apparatus

Figure 12 shows the essential features of the experimental tube. The electron beam is provided by a standard electron gun ordinarily incorporated in type 5C cathode ray tubes. The gun and deflecting plate assembly, *G* and *D*, are mounted on a 14 lead tungsten-glass seal. A truncated tantalum cone *S* is introduced between the gun assembly and the target chamber for electrical shielding purposes. The collector *C* and guard electrode *B* are fabricated of tantalum. A helical tungsten filament *F* is mounted adjacent to *B*. Collector *C* may be heated by electron bombardment from *F*. To permit measurement of both thermionic and secondary emission parameters, the supporting structure for target-cathode *T* is identical with that described in Section III, A, 2.

After vacuum-firing various components in separate glass envelopes, the principal steps in processing the tubes on the vacuum system included:

(1) 450° C. vacuum bake for 2 hours;
(2) Preliminary degassing of tantalum cone and electron gun assembly by induction heating;
(3) Degassing of collector assembly at a temperature of 1200° C.;
(4) Conversion and activation of electron gun cathode;
(5) Conversion and activation of target cathode;
(6) Final degassing of all metal parts;
(7) Final 300° C. bake.

During these operations, the target cathode was in position inside the Kovar anode *A*.

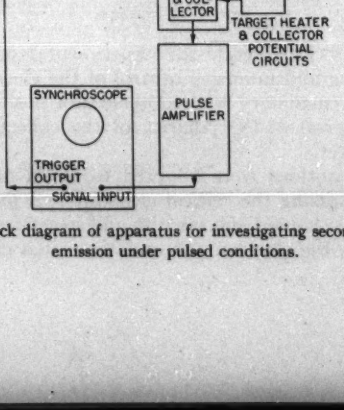

FIG. 13. Block diagram of apparatus for investigating secondary electron emission under pulsed conditions.

For the short-time studies, low-voltage recurrent rectangular pulses applied to the control electrode of the electron gun maintained the bombardment for periods of the order of 10^{-6} sec. The arrangement for accomplishing this is illustrated schematically in Fig. 13. The modulator triggered by synchroscope feeds a high negative pulse to the pulse-clipper circuit. The resulting positive rectangular pulse is then impressed upon the control electrode of the electron gun. Short-time changes in the current to or from the target are observed on the screen of the cathode ray tube in the synchroscope, after amplification by a high-gain pulse amplifier from which the D.C. thermionic current is excluded. Details of the pulse-clipper and pulse-amplifier circuits appear in Figs. 14 and 15.

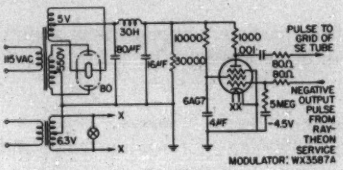

FIG. 14. Circuit for clipping modulator pulses for application to control electrode of electron gun.

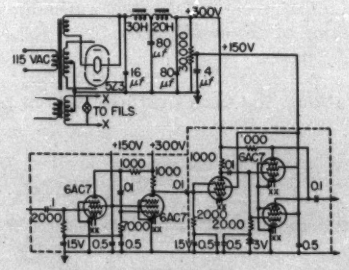

FIG. 15. Video amplifier circuit used for observation of pulses on indicator tube of synchroscope.

The circuits associated with the experimental tube are shown in Fig. 16. Focussing and intensity control of the electron beam are accomplished in the customary manner, as is spot positioning. A switch permits rapid reversal of the polarity of the collector electrode with respect to the target.

Elaborate precautions were adopted to avoid all possibilities for electrical pick-up among the critical elements. A metal cabinet, with metal-lined shelves, housed the circuits and experimental tube. As is evident in Fig. 17, the electron gun and associated circuit elements as

well as the pulsing equipment, were completely shielded from the target-collector system and pulse amplifier. Furthermore, the various circuits were individually shielded, and A.C. lines entered the individual compartments through filter networks.

D.C. and pulsed measurements of the yield could be made practically simultaneously. With collector positive, Meter I_s indicates the current from the target. When the bombarding beam is on, this is comprised of both secondary and thermionic electrons. The latter can be measured by cutting off the beam with high negative bias on the control electrode. Meter i_T measures primary and secondary currents with the collector positive, or primary current alone with the collector negative.

For the pulsed observations, the gun control electrode is biased beyond cut-off, and flat-top positive pulses of approximately 25 volts

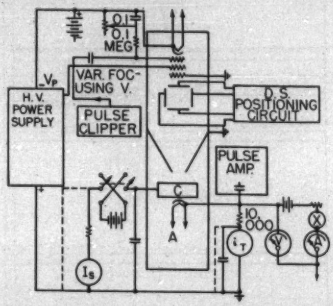

FIG. 16. Circuit diagram of experimental arrangement for investigations of secondary electron emission under pulsed bombardment.

from the pulse clipper turned the beam on for microsecond intervals at various recurrence frequencies between 500 and 4,000 pps. All voltages in the system other than this low-level modulating pulse were constant. Traces on the synchroscope screen were observed visually, and in some instances simultaneously photographed.

The yield is determined most conveniently by viewing the target current with V_c alternately positive and negative. Then:

$$\delta = \frac{I_s'}{I_p'} = \frac{i_T(V_c^+)}{i_T(V_c^-)} + 1, \tag{13}$$

where

I_p' = primary current = $i_T(V_c^-)$,
I_s' = secondary current = $i_T(V_c^+) + i_T(V_c^-)$.

Steady thermionic emission must be taken into account in the D.C. measurements.

The spot due to the fluorescence of the target under electron bombardment was visible. The focus of the beam, and position of the spot on the target could, therefore, be observed. By means of the deflector electrodes, it was possible to explore various points on the target surface with the primary beam.

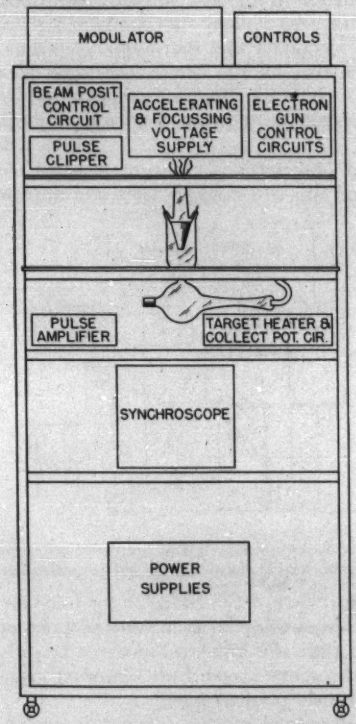

FIG. 17. Rear view, schematic, of pulsed secondary emission apparatus. The various compartments were individually shielded.

3. *Results*

(a) *Increase of δ with Temperature*

Figure 18 shows tracings of photographs of pulses observed on the screen of the cathode ray tube in the synchroscope. It is apparent that the pulsed secondary emission increases with temperature, just as in the case of the D.C. measurements.

(b) Comparison Between D.C. and Pulsed Data

Two tubes of the type shown in Fig. 12 were constructed. Because of the poisoning effects upon the cathode emanating from the commercial electron gun assembly during the activation procedure, the degree of activation of both target cathodes was lower than the average attained in S.E. tubes, as was evidenced by both the pulsed thermionic emission and the secondary emission characteristics. However, despite the smaller absolute value of the yields compared with those obtained with S.E. tubes, all of the pertinent features could nevertheless be investigated.

The Yield vs. Energy relationship for tube No. 2 appears in Fig. 7, whereas curve VI, Fig. 9, is a plot based upon the Yield vs. Temperature data. Except for absolute magnitudes, the characteristics are similar

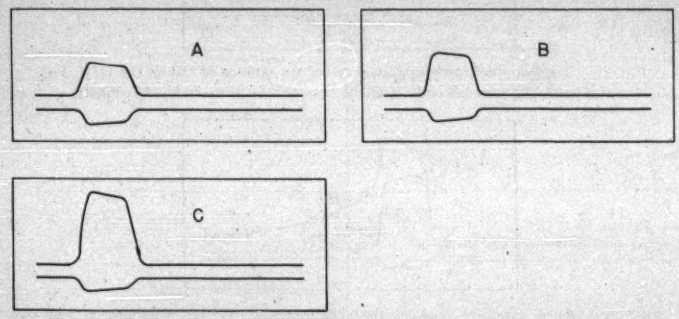

FIG. 18. Typical synchroscope traces showing target current with collector voltage alternately positive and negative. The upper pulse, $i_T(V_c+)$, is equal to the secondary current I_s' emitted by the target minus the primary current I_p' bombarding the target. The lower pulse $i_T(V_c-)$ represents primary current I_p'. The pulse duration is one microsecond. Thermionic emission is zero in all instances. Tube Spec. S.E. 1. *A*. Room temperature, $\delta = 3.3$. *B*. 130° C., $\delta = 4.3$. *C*. 350° C., $\delta = 7.0$.

to those obtained with various other types of tubes. Practically simultaneous measurements of pulsed and D.C. yields were in good agreement at all temperatures ranging from room temperature up to the maximum temperature for which the data are plotted.

(c) Observations of Tail and Simulation of Same

When the cathode is heated above a critical temperature, a tail on the $i_T(V_c^+)$ pulse (the origin of which will become apparent presently) persisting after the cessation of the primary pulse, begins to appear, as is shown in Fig. 19. This is accompanied by a corresponding change in the pulse shape, specifically growth in amplitude during the duration of the microsecond. Fig. 20 shows two traces exposed on the same

film (*A*) photographed at a temperature just below the threshold for the onset of the phenomenon, and (*B*) taken at a target cathode temperature at which the effect has become quite pronounced. It is this phenomenon which Johnson has interpreted as "enhanced thermionic emission."

During the present experiments, however, it was observed that the nature of the tail depends quite markedly upon the position of the bombarding beam, which in this case could be caused to explore the target cathode surface by means of the spot positioning arrangement. In Fig. 21, (*A*) manifests a definite tail whereas (*B*) does not. These pic-

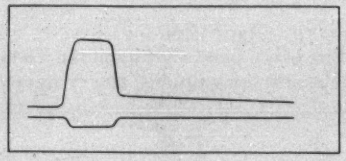

FIG. 19. Typical synchroscope trace showing appearance of tail on the $i_T(V_c+)$ pulse persisting microseconds after the cessation of primary bombardment.

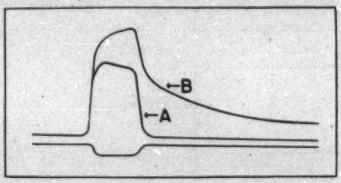

FIG. 20. Double exposure showing the appearance of the tail phenomenon and the effect upon the shape of the pulse. (*A*) Target cathode temp. = 400° C. (*B*) Target cathode temp. = 800° C.

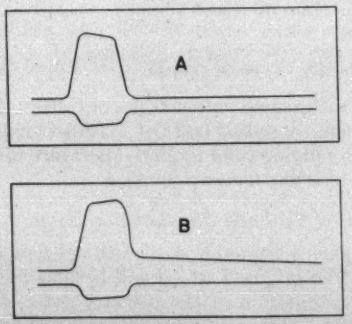

FIG. 21. Synchroscope traces showing change in appearance of the tail introduced by shifting position of primary beam from (*B*) to (*A*). All conditions other than spot position were kept constant.

tures were obtained in rapid sequence, effecting a change in nothing but spot position between exposures. This observation was consistent with the expectation that the tail might arise as a consequence of certain instrumental considerations which could be sensitive to the geometry.

As is evident in Fig. 12, the target cathode T may be moved away from the collector electrode C thereby exposing the pure tantalum electrode B to the electron beam, and permitting the latter to serve as a

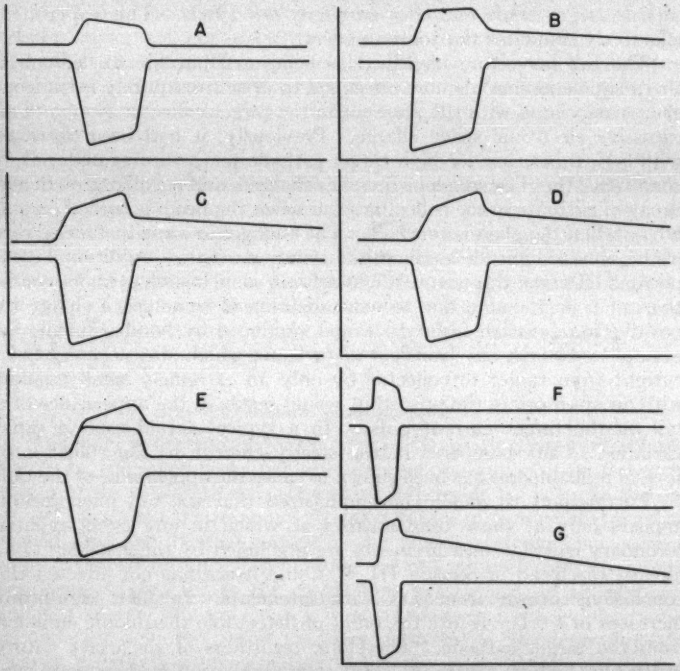

FIG. 22. Traces obtained by bombardment of tantalum target with adjacent tungsten filament, F. Square pulses are 1 microsecond long. (A) No thermionic emission from F; $\delta = 1.3$. (B) Thermionic emission from $F = 1.5$ ma. (C) Thermionic emission from $F = 1.7$ ma. (D) Thermionic emission from $F = 1.8$ ma; saturation sets in. (E) Double exposure, with thermionic emission on and off. (F) and (G) Same as above, with slower sweep speed.

target. The beam may be positioned between the rods R and focussed on B alone, or partially on the helical filament F. The traces in Fig. 22 were obtained in this manner. The photograph (A) was taken at room temperature. The yield δ is equal to 1.3, in good agreement with previous measurements on tantalum targets.[14] However, when the filament F is heated above a critical temperature, nothing else being

disturbed, a marked change occurs. A tail begins to appear, as in Fig. 22(*B*), and the effect becomes more pronounced upon further increase in the temperature of *F*, as in Fig. 22(*C*), until saturation sets in. The critical temperature of *F* turns out to be that at which thermionic emission becomes copious. It is particularly significant that *the tail observed with the tantalum target occurs when the D.C. thermionic current from F is of the same magnitude as that emitted by the oxide-coated cathode targets when the latter manifests tail effects.* This experiment effectively simulates the Johnson effect.

The tail heretofore identified as being attributable to "enhanced thermionic emission" is now presumed to arise from purely extraneous causes associated with the presence in the target-collector system of an excessive electronic space charge. Previously, it had been observed with S.E. tubes that for high target cathode temperatures under D.C. conditions, the glass envelope becomes charged, and peculiar growth and decay of currents to the collector occur when the beam is turned on and off, or when the glass is touched. The changes in some instances were of the same magnitude as the initial steady currents. Additional complicated effects of this nature might arise in some instances under conditions of poor vacuum, due to neutralization of some space charge by positive ion emission from the target produced by bombardment, for example. In fact, any transient disturbance which alters the net D.C. current from target to collector by only an extremely small amount with an appropriate time-constant would result in the appearance of a tail on the target current pulse. In a typical actual case, a rapid variation of microamperes in the steady current to the collector of several milliamperes has been shown to cause the appearance of the tail.

Furthermore, it should be emphasized that the tail phenomenon appears only at those temperatures at which in any event reliable secondary emission measurements are precluded by the considerations already discussed in Section III, B, 2 and hence has not affected the conclusions drawn from D.C. measurements. In fact, significant increases in δ occur before the onset of detectable thermionic emission from the target cathode. Therefore, regardless of the exact nature of the effect which causes the short-time fluctuation in the steady current from target to collector, the phenomenon must be considered as being not pertinent in discussions regarding the true secondary emission from an oxide-coated cathode. On the contrary, it depends critically upon certain experimental factors including the geometrical disposition of components of the experimental tube, and is a property to be associated with space charge rather than with the target itself.

V. FACTORS PERTINENT TO THEORY.

A. Effect of Coating Resistance.

A possible explanation for the increase of yield with temperature might be sought in the electrical conductivity characteristics of the

oxide-coated cathode. If the resistance is sufficiently high to cause an appreciable fall of potential in the coating at room temperature, it would be expected that the decrease in resistivity with increase in temperature might enhance the apparent yield, from that characteristic of an insulator at room temperature to that of a conductor at high temperatures. There are several reasons for considering this improbable in the present experiments:

(1) The absence of time effects upon bombardment of targets at room temperature, particularly with microsecond pulses, indicates that the influence of coating resistance is negligible. For high resistance, variations of the secondary current with a time constant RC, where C is a capacitance of the target coating and R its resistance, would be expected to arise.

(2) The resistivity of coating of this type, prepared according to approximately similar techniques, has been measured by W. E. Danforth [15] using cathodes containing embedded probes. Danforth observed resistances ranging from 50,000 ohms to perhaps as high as 10 megohms occasionally. For the electron currents here involved, the effect of this resistance is negligible. However, it is not difficult to conceive of situations involving cathodes less active than those used here, where the resistance might be considerably higher than the aforementioned upper limit, thereby introducing pulsed effects at low temperatures.

B. Resolution of Dilemma Regarding Conservation of Energy.

Difficulty in accounting for the high yields, particularly extrapolated values of 100 secondaries per primary, became apparent in the early stages of the investigation. It seemed impossible to reconcile the observed data with the principle of conservation of energy, if it was assumed that the average energy of the secondaries was even several volts. Consideration of competing processes, preferred directions, solid angles, etc., led to the conclusion that apparently an excessive fraction of the primary energy was manifesting itself as observable secondaries. Studies were therefore undertaken to determine the energy distribution of secondary electrons under various conditions. Where experimental data are comparable, the results are at least in qualitative agreement with those reported by Morgulis and Nagorsky.[5]

The tube described in Section IV, B, 2 was particularly well adapted to this phase of the investigation. The measurements were obtained by applying retarding potentials V_c^- to the collector, and observing the current I_s (see Fig. 16). This provides data for plotting an integral distribution. For any negative value of V_c, the current I_s to the collector is given by:

$$I_s = \int_{V_c}^{\infty} N(E)dE. \tag{14}$$

where $N(E)dE$ represents the number of secondaries in the interval dE at E. Differentiation with respect to the lower limit gives the differential energy distribution, or the original function:

$$N(E) = -\frac{dI_s}{dV_c^-}. \tag{15}$$

Secondaries emerging from the target surface into the vacuum in all directions are included in these measurements.

1. *Energy Distribution as a Function of Primary Energy*

Figure 23 shows curves of I_s vs. V_c^- at two primary voltages, with the cathode at room temperature. The energy distributions derived from these curves appear in Fig. 24. Increasing the bombarding energy

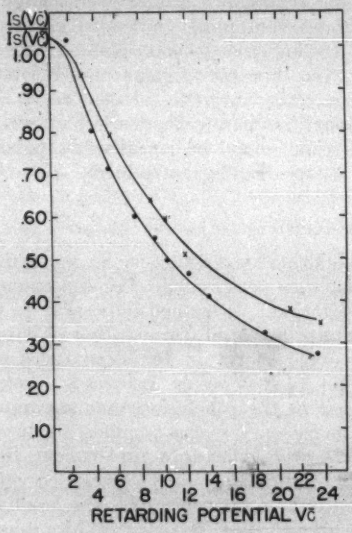

FIG. 23. Curves showing secondary electron current vs. retarding potential applied to collector electrode, at room temperature. × Primary voltage $V_p = 600$ v. ● Primary voltage $V_p = 1{,}600$ v.

results in a shift of the maximum and average energies to lower values. This increase with V_p in the number of slow electrons may be attributed to the greater depth of penetration of primaries, and the subsequent additional energy losses suffered by secondaries which, on the average, must traverse a longer path before emerging from the surface. A

change in collision cross-section with energy might also be responsible for a shift.

2. *Energy Distribution as a Function of Temperature*

Figure 25 contains curves of I_s vs. V_c^- at room temperature and at two elevated temperatures, for a fixed primary voltage. The energy distributions under these conditions appear in Fig. 26. It is evident that a considerable change occurs, with a marked shift of the maximum toward lower energies as the temperature is raised. It seems unlikely that the magnitude of this effect is consistent with that expected solely

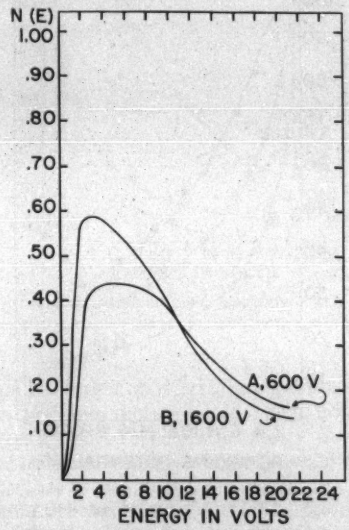

FIG. 24. Energy distribution curves for two primary energies at room temperature. *A*—Primary voltage V_p = 600 v. *B*—Primary voltage V_p = 1,600 v.

by virtue of the increased amplitude in the thermal vibrations of the lattice and the resulting small additional energy loss per interaction. The difference might be accounted for by the production of tertiaries by the secondary electrons, a process which could also be invoked to account for the increased yields.

The shift in the energy distributions cannot be explained as an experimental consequence of the variation of coating conductivity with temperature. The $I_s R_T$ drop in the target, even at room temperature, was negligible in the present instance. Furthermore, thermionic emission has not been involved in any of the curves, inasmuch as it was still

negligibly small compared with secondary emission at the highest temperature cited.

3. *Total Emergent Energies*

The difficulty regarding the conservation of energy is obviated by the decrease in average secondary energy associated with the increase in the yield. It is illuminating to represent the data in the form of the curves shown in Fig. 27. Here I_s is again plotted as a function of V_c^-.

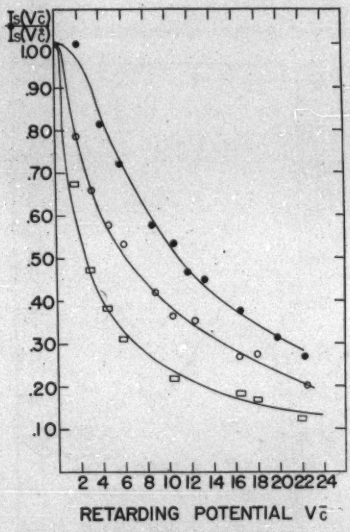

FIG. 25. Curve showing secondary electron current vs. retarding potential applied to collector electrode at constant primary energy V_p = 1,600 volts. Thermionic emission was just commencing at the highest temperature. ○ 470° C. □ 615° C. ● Room temperature.

Rather than normalizing all the data to unity, as was done in Fig. 25, the relative magnitudes of $I_s(V_c°)$ are here adjusted to represent the observed dependence of yield upon temperature for the particular target cathode concerned. It is evident that corresponding to each $I_s(T_n)/2$, the median value of the energy of secondary electrons is $V_m(T_n)$.

The average value of the secondary electron energy, V_{av}, is obtained from the energy distribution curves of Fig. 26. The mean emergent energy per incident primary is equal to $V_{av}\delta$, and the data summarized in Table V indicate that this total emitted energy at first increases only slightly, if at all, and thereafter even decreases as the temperature is raised.

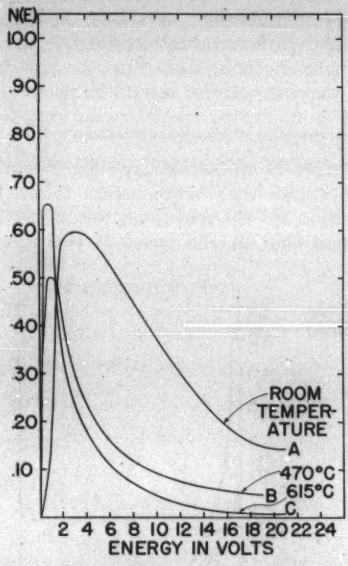

FIG. 26. Energy distribution curves for three temperatures at a constant primary energy V_p = 1,600 volts. The shapes, but not the relative amplitudes, may be compared. *A*—Room temperature. *B*—470° C. *C*—615° C.

The yields from the target used in these experiments were lower than those obtained in previous measurements with S.E. tubes containing more active emitters. It is therefore necessary to assume that in the latter cases, the average secondary energies were even lower than those indicated above. This is tantamount to predicting that the secondary energy distribution might vary as a function of the degree of activation of the oxide-coated cathode target. An attempt was made to improve the emission from the cathode by a treatment involving pulsed ageing as a thermionic cathode in the diode position. Unfortunately, only a small but distinct change in emission was thus induced, and although

TABLE V.

Total Emergent Secondary Energy Per Incident Primary

Temperature, ° C.	Yield, δ	Mean Energy of Secondary Electron, V_{es}	Mean Secondary Energy in eV., Per 1,600 Volt Primary, $V_{es}\delta$
Room temp.	2.0	11.7	23.4
470	3.1	8.5	26.3
615	5.3	3.7	19.6

the resulting energy distribution, as shown in Fig. 28, displayed a change exceeding the experimental uncertainty, it obviously cannot yet be regarded as being too conclusive. Further experiments embracing cathodes of widely varying activity should be performed.

C. Mechanism for Temperature Dependence of Yield.

The mechanism whereby the secondary electron emission from oxide-coated cathodes increases with temperature is not well understood. An obvious explanation for the additional secondary currents at temperatures higher than that at the onset of thermionic emission was

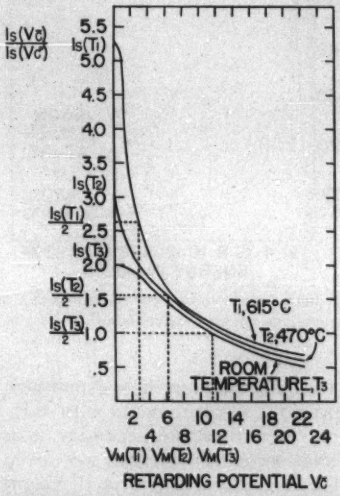

FIG. 27. Integral distribution curves adjusted at $V_c = 0$ for relative change in δ with temperature. $T_1 = 615°$ C. $T_2 = 470°$ C. temperature.

sought in terms of local temperature rise of the target surface due to electron bombardment. Calculations based upon the experimental conditions indicate that this hypothesis is precluded. Johnson[13] has also pointed out that this is far too small to explain the effect. Finally, the increase in yield observed in the absence of thermionic emission could not be accounted for in this way.

The similarity of the functional relationship here and in the case of the electrical conductivity appears to be significant (see Fig. 9, Curve IV), i.e.,

$$\Delta\delta = Ae^{-Q_1/2kT}. \qquad (16)$$

This result might be understood as follows: In general, secondary emission depends directly upon the number of electrons available in the conduction band. In the alkaline earth oxides, as in other semi-conductors, the number of valence electrons is just sufficient to fill an energy band, so that, if no excitation occurs, as is the case for low temperatures, no electrons are available for conduction. With increase of temperature, however, thermal excitation to higher-lying bands (conduction bands) occurs. It is these electrons which are responsible for the electronic conductivity of semi-conductors at higher temperatures,

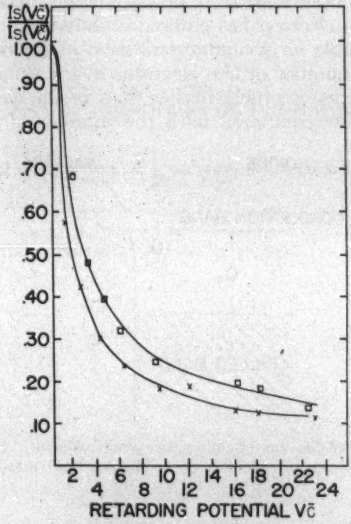

FIG. 28. Integral distribution curves showing effect of activation at primary energy V_p = 1,600 volts, and temperature = 615° C. □ Initial data. × Data after attempt at activation.

and which it might be assumed are also available for secondary emission. Quantitatively, the yield vs. temperature dependence would then result from the fact that the electronic population in the conduction band is proportional to the Boltzman factor exp. $(-Q_1/2kT)$ where Q_1 represents the excitation energy, i.e. the energy difference between bands. Actually the alkaline earth oxides are impurity semi-conductors, the impurity taking the form of free metal (Ba, Ca or Sr) atoms scattered throughout the oxide. The free atoms provide discrete energy levels which are localized in the forbidden energy region between the filled and conduction bands. The electrons from impurity levels, therefore, re-

quire a smaller excitation energy and Q_1 should be identified with this energy required to excite electrons from the impurity level to the conduction band (see Fig. 29).

Thus, provided the work function does not vary sensitively with temperature and the physical characteristics of the system are preserved as the temperature increases, the yield-dependence upon temperature is given by the corresponding density of conduction electrons.

Theoretical difficulties exist, however, As Fröhlich[16] has pointed out, the laws of conservation of energy and momentum render it improbable that a free (conduction) electron would emerge in the direction from which the primary electron has entered. Only bound electrons would therefore be available for secondary emission in the required direction. Furthermore, the number of free electrons in the semi-conductor, even at high temperatures, is much smaller than in the case of metals. In any event, it is low compared with the number of bound electrons,

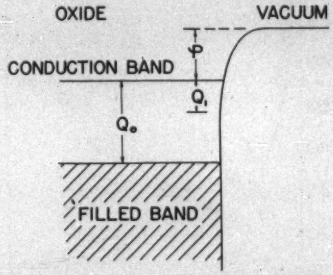

FIG. 29. Energy-level diagram for an impurity semi-conductor. Q_1, the energy required to excite electrons from the impurity level to the conduction band, may be obtained from data plotted in Fig. 9.

which must constitute the main source of secondary emission at lower temperatures. These theoretical difficulties appear to be of a fundamental nature, and will probably be resolved only by the formulation of a new model for the process of secondary emission from an impurity semi-conductor of this type.

VI. ACKNOWLEDGMENTS.

It is a pleasure to acknowledge valuable assistance rendered by Daniel L. Goldwater during several phases of these investigations. The Cathode Research Group of M.I.T. Radiation Laboratory, with which a valued close collaboration was maintained throughout the course of this project, supplied cathode targets of various descriptions for the present experiments. In the latter connection, appreciation is expressed particularly to E. A. Coomes, J. G. Buck, and A. Fineman.

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Engineers Report Destruction of Navy Hangars Due to Unprecedented Wind Load.—Collapse of the three Navy "blimp" hangars during the recent Florida hurricane was caused by a wind load exceeding two-and-a-half times that for which the structures were designed, states a joint report, approved for publication by the Navy, and delivered before the 30th annual meeting of the Building Officials Conference of America by Frank J. Hanrahan, structural engineer of the National Lumber Manufacturers Association.

Also concurring in the findings were Verne Ketchum and J. F. Haldeman, Timber Structures, Inc.; F. A. Hartman and R. C. Bastress, Pretexol Corporation; R. H. Bescher of the Wood Preserving Division, Koppers Company, Inc., and Henry Garnjobst, Jr., American Lumber & Treating Company. These seven technical men, who examined the destruction at the site immediately after the hurricane, made every effort to collect and correlate all available, reliable data.

In his preliminary remarks, Hanrahan pointed out that, as in the case of the Knickerbocker Theatre, Cocoanut Grove Club, and Tacoma Bridge disasters, many important lessons may be learned from such mishaps.

High points of the joint report are:

1. Each of the three hangars, having exterior dimensions of approximately 300 feet width, by 1,060 feet length, by more than 180 feet height, with no interior partitions, collapsed separately during the peak, or near peak, winds of the hurricane.

2. Intense, sustained fires, exceeding 2,000° F., were started and fed by the contents of each hangar separately following collapse. The 25 "blimps," 366 airplanes, and 150 automobiles housed in the hangars contained large quantities of high octane gasoline believed ignited by electrical shorts or sparks caused by aircraft batteries, metal parts of planes, concrete floors or electrical circuits being struck by falling timbers with metal fastenings.

3. Although U. S. Weather Bureau reports over a period of 33 years showed the extreme wind velocity (fastest mile of wind) measured at Miami to be 96 m.p.h., the structures were designed to resist a wind of 110 m.p.h. Available meteorological data indicate the winds during the September 15, 1945, hurricane exceeded 175 m.p.h. at the Richmond Naval Air Station. It would be unreasonable to expect the structures to withstand the high overload imposed and the failure may be considered an "Act of God."

4. No evidence of faulty design, materials, treatment, fabrication, erection or maintenance was found.

5. Even though untreated interior portions of the wood members were often exposed by breakage in falling from great heights, the fire-retardant treatment of the wood prevented or assisted in preventing fire and spread of fire where the fire was not fed directly by the highly combustible contents of the buildings, such as high-octane gasoline. There was no spread of fire to other buildings on the base in spite of the high winds, and the fire-retardant treated wood did not itself support combustion.

6. The timber connectors found on the site were of the specified size and type and of standard make. No evidence of failure of connectors or bolts was found.

R. H. O.

NOTES FROM THE NATIONAL BUREAU OF STANDARDS.*

CRYSTALLIZATION OF UNVULCANIZED RUBBER.

Natural rubber is commonly classed as an amorphous substance and regarded as distinctly different from those classed as crystalline. However, under the proper conditions—usually involving cooling or stretching, or both—rubber exhibits all the phenomena to be expected in the formation and melting of a polycrystalline material. Crystallization and fusion are made manifest by changes in specific volume, specific heat, light absorption, birefringence, X-ray diffraction, and mechanical properties. Studies of crystallization in rubber, using a number of these techniques, have been made at the Bureau.

In the May issue of the *Journal of Applied Physics* and in the *Journal of Research* for June (RP1718), Lawrence A. Wood and Norman Bekkedahl give the results of a series of quantitative studies of the crystallization of unvulcanized rubber as a function of temperature. Conditions that might influence the results were purposely kept as simple as possible. The main features of the crystallization of vulcanized rubber have already been shown to be similar to those of unvulcanized rubber, the vulcanization merely causing a decrease in the rate.

Stretching obviously adds complications to the experimental conditions, and so was not employed. Change of volume, as measured in a mercury-filled glass dilatometer, was chosen as the simplest method of measuring crystallization, and the one most likely to yield quantitative data about the course of crystallization or fusion.

Crystallization was observed to occur at temperatures between $-50°$ and $+15°$C., and to be most rapid at about $-25°$C. The final decrease of volume on crystallization was usually found to lie between 2.0 and 2.7 per cent.

The melting of crystalline rubber was found to occur over a range of temperatures, and to be closely related to the temperature at which the crystals were formed. The temperature at which the beginning of melting occurs is from 4 to 7 degrees above the temperature of crystallization. The range of melting is about 35 degrees at the lowest temperatures and decreases to about 10 degrees at the highest. The same range of temperature of melting is obtained, regardless of the extent of the crystallization.

* Communicated by the Director.

The nature of the crystalline regions in long-chain high polymers has been the subject of considerable discussion in recent years. It seems generally agreed that the structural units of the crystallites are not whole molecules, but rather kinetic units that are segments of chains. Consequently, a single chain may contain segments that are units in two or more different crystallites, joined by segments that are to be regarded as part of the amorphous material. However, no detailed picture has been proposed that logically and satisfactorily explains the fact that the range of melting is not dependent on the extent of crystallization and that it is definitely determined by the temperature at which crystallization occurs.

SERVICEABILITY OF OPTICAL GLASSES.

The pH-responses of electrodes prepared from glasses of widely different compositions have been compared with the hygroscopicity of the glasses (*Technical News Bulletin* No. 348 (April 1946)). The results, which are given in a report (RP1719) by the Donald Hubbard in the June *Journal of Research*, strongly support the belief that adequate hygroscopicity is a primary factor in determining the suitability of a glass for pH measurements. The data also suggest that the pH-response might well be used as a measure of the serviceability of optical glasses, i.e., their ability to maintain a clear polished surface upon exposure to the atmosphere.

NICKEL PLATING ON STEEL BY CHEMICAL REDUCTION.

A process developed by Abner Brenner and Grace E. Riddell of the Bureau's Electrochemistry Section for nickel-plating steel without the use of an electric current, will be described in a paper to be presented by Dr. Brenner at a meeting of the American Electroplaters Society in Pittsburgh on June 17. The deposition is brought about by the chemical reduction of a solution of a nickel salt with hypophosphites. The reaction is catalyzed by steel and nickel, and deposition of nickel occurs only on the surfaces of these metals. Because of its cost this process will not displace electrodeposition, but it should have certain special applications, such as the plating of articles that cannot be electroplated satisfactorily.

PURIFICATION OF RHODIUM PLATING BATHS.

Thin coatings of rhodium, when electrodeposited under proper conditions, have a reflectivity of approximately 75 per cent., and are very resistant to tarnish. This combination of properties makes rhodium electrodeposits very desirable as coatings on searchlight reflectors and also useful in the jewelry industry. Rhodium plating baths contain

from 1 to 2 grams of rhodium, as the complex phosphate, 7 milliliters phosphoric acid, and 25 milliliters of sulfuric acid per liter. When properly operated such baths will last for long periods of time and still produce excellent coatings, but, if the bath becomes contaminated through accident or long use, inferior coatings that are dark or cracked are obtained. Owing to the high cost of rhodium, it is necessary to reclaim the contaminated bath either by returning it to the vendor for purification or to purify the solution at the plating establishment.

A simple method, one that can be used even in a plating shop, for reclaiming the contaminated baths has been developed by Abner Brenner and Walter A. Olson of the Bureau's Electrochemistry Section. The undesirable metallic impurities are precipitated with potassium ferrocyanide and removed by filtration. The rhodium in the complex phosphate is not precipitated under the conditions of purification.

QUALIFICATION TESTING OF DRY CELLS AND BATTERIES.

The so-called quick tests made on dry cells and dry batteries give little information about the service output or relative merits of various brands. The test that best represents any particular service is that which most nearly duplicates the rate-of-energy output of the battery in actual use. Intermittent tests are preferred to continuous tests, since there is no direct relation between the results of continuous tests and intermittent tests of longer duration.

Twenty years ago, the Bureau undertook the qualification testing of dry batteries, selecting the samples periodically at the manufacturers' plants and subjecting the batteries to a complete program of tests in accordance with the Federal specifications. The results were supplied to the various Government departments, and each manufacturer was informed of the results of tests on his own product. This service was necessarily suspended during the war. It is now to be resumed at the request of several Government agencies and manufacturers. In reconverting the equipment, the control apparatus is being modernized.

30 Billion Board Feet.—How much wood in the form of lumber is used in the United States in an average year?

The answer is 30 billion board feet, which does not mean much to the average inquirer, because the number is too big for comprehension.

To emphasize that the figure is truly of an astronomical vastness, a Forest Service statistician has put the lumber into an imaginary board walk. The walk is thirty feet wide and one inch thick and reaches all the way to the moon.

One-half that amount, the Forest Service says, ordinarily goes into building construction. The other half is for all sorts of manufactured articles, boxes, furniture, matches, millwork, toys, and many other uses.

A second, and highly important, use of wood lies in its contribution to intellectual life, in providing cheap material for printing books, magazines, and newspapers. Newsprint accounts for about a fourth of the wood-pulp consumption.

Wood remains of great importance as a fuel.

R. H. O.

60,000 KVA Synchronous Condensers.—Now rapidly nearing completion at the Schenectady Works of the General Electric Company are two 60,000-kva-hydrogen-cooled synchronous condensers for the High-Grove Substation of the Southern California Edison Company. The two units will be coupled together and used initially as a frequency-changer set to convert 60-cycle power from Boulder Dam to 50 cycles for feeding into the Southern California System.

Rating of the machine to be used as the 60-cycle end of the frequency-changer set is 12 pole, 60,000 kva, 600 r.p.m., 13,800 volts, 60 cycles; while the driven end is rated 10 pole, 50,000/60,000 kva, 600/720 r.p.m., 11,500/13,800 volts, 50/60 cycles. The rating of both units is based on hydrogen pressure slightly above atmospheric.

Ultimately, the machines will be separated and both will operate as straight 60-cycle synchronous condensers.

Utilized on each machine is a direct-connected exciter operating in hydrogen. General Electric is the only manufacturer to furnish direct-connected exciters operating in hydrogen, and this is the first time they have ever been used on units of this size. Previous top rating was on machines of 18,750 kva.

Each unit is approximately 16 feet in diameter and 28 feet long. Weight is 522,000 pounds and the total gas capacity is 3,200 cubic feet.

R. H. O.

THE FRANKLIN INSTITUTE.

MEDAL DAY PROCEEDINGS.

The annual reception, dinner and presentation of awards, known as Medal Day, took place at The Franklin Institute on Wednesday, April 17, 1946. The reception started at 6:45 P.M. and dinner was served at 7:30 P.M. Mr. Charles S. Redding, President of the Institute, presided at the dinner and the award of medals which followed.

RECEPTION.

The Hostess Committee of The Franklin Institute gave a reception in the rooms adjoining Franklin Hall to the medalists and other guests immediately preceding the dinner. Approximately four hundred and twenty attended. Dinner was served immediately following the reception.

At the end of the dinner Mr. Redding called upon Captain Guy Marriner to play the National Anthem, stating that Captain Marriner is now a permanent member of the staff, having been released recently from services in the army where he established a notable record.

Mr. Richard T. Nalle, Vice-President of The Franklin Institute, and Chairman of the National Franklin Committee was then called upon to give a toast to Benjamin Franklin. Mr. Nalle asked the guests to pay this tribute and the toast was drunk (in water).

STATED MONTHLY MEETING.

The sponsors for the medalists of 1946 were then called to their places, and the President asked that this, the stated monthly meeting of The Franklin Institute, please come to order. He stated that the minutes of the February meeting had been published in full in the March issue of the JOURNAL and, if there were no objections, they would be declared approved as printed. They were so approved with no dissent.

MR. REDDING (continued): On behalf of the officers and the members of the Board of Managers of The Franklin Institute, I am very happy to welcome you to our Medal Day meeting. That I do most heartily. This is the fifth Medal Day dinner at which I have presided as President of the Institute, but the first which has been held under peace-time conditions. These occasions are always pleasant but this one should be particularly so because the war is over and we can meet in the joyous spirit which prevailed prior to 1942.

We are here in a spirit of fine fellowship to honor outstanding men of science and engineering, men whose works have contributed to the advancement of our civilization—men whose works will live down through the years to come. All honor to them, and we, members and friends of The Franklin Institute, are happy to have them with us tonight.

May I, at this time, express the thanks of all present to our Hostess Committee which, with the able assistance of Miss Connelly, its secretary, was entirely responsible for the reception preceding this meeting. That Committee, under the fine leadership of Mrs. John White Geary, adds much to the pleasure of this and other Institute gatherings. Unfortunately Mrs. Geary is ill this evening and is unable to be with us. We hope for her speedy recovery.

It is our custom to invite to our Medal Day meetings, as our guests, those who, in previous years, have received Franklin Institute Certificates and Medals. There are twenty-one such with us this evening. To you former Medalists I extend a particularly warm welcome. You are a part of The Franklin Institute family, and we are delighted to have you with us. I will read, in chronological order, the names of the former medalists who are with us and will ask each medalist to rise as his name is called and to remain standing until the complete list is read. Will the audience please withhold applause until the last name is announced?

FORMER MEDALISTS ATTENDING MEDAL DAY—1946.

Year of Award	Medalist	Medal
1904	Clamer, Dr. G. H.	Cresson
1911	Hepburn, Dr. Joseph S.	Longstreth
1921	Hepburn, Dr. Joseph S.	Certificate of Merit
1918	Creighton, Dr. H. Jermain	Longstreth
1939	Creighton, Dr. H. Jermain	Potts
1920	Kothny, Mr. G. L.	Longstreth
1923	Parks, Mr. Harry S.	Longstreth
1924	McBride, Mr. Thomas C.	Longstreth
1926	Smathers, Mr. James F.	Longstreth
1930	Gibson, Mr. Norman R.	Cresson
1930	Moultrop, Mr. Irving E.	Cresson
1931	Davisson, Dr. Clinton J.	Cresson
1932	Wenner, Dr. Frank	Wetherill
1932	Harrison, Mr. Thomas R.	Certificate of Merit
1936	Hall, Mr. Peter P. G.	Longstreth
1937	Eksergian, Dr. Rupen	Henderson
1945	Eksergian, Dr. Rupen	Levy
1938	Kutz, Mr. Stewart S., Jr.	Levy
1939	Chaney, Dr. Newcomb K.	Potts
1939	Wilford, Mr. E. Burke	Certificate of Merit
1940	Slayter, Mr. Games	Longstreth
1941	Wilson, Mr. Benjamin J.	Longstreth
1943	Bull, Mr. Anders	Levy
1944	Stokes, Mr. J. Stogdell	Longstreth

MR. REDDING: Thank you, gentlemen, for honoring us this evening by your presence.

At each stated meeting of The Franklin Institute we have a report from our Secretary. Dr. Henry Butler Allen is a very busy man, combining the duties of Secretary of the Institute with those of Director of its Museum, and now Director of a new Institute activity about which I understand he will speak. During the war years, in addition to his other duties, he conducted the extensive War Research and Development work carried on at the Institute with such conspicuous success that the Institute was honored by high awards from both the Army and Navy. Dr. Allen will now present his report, to which he has given the title "Reconversion." Dr. Allen:

REPORT OF THE SECRETARY.

DR. ALLEN: When I got to thinking about what might interest you about our reconversion activities at the Institute I began to doubt the choice of the title for my remarks. For on second thought reconversion seems to mean a turning back to conditions as they were. We are definitely not doing that: the world has changed, and we aim to keep abreast.

One of our most important reconversion tasks lies in our Museum. Science has entered a new era. We must translate it for the man on the street and our school teacher friends with their hundreds of thousands of pupils. We are preparing for a complete restudy of our Museum, and will carry out our reconversion just as rapidly as that necessary commodity, *funds*, are available. I use the name Museum. We have not yet found a recipient for our prize for a better title. The word Museum still connotes to many people a repository for antiquities, or at best static objects. Ours, and others today are dynamic laboratories where the visitor sees, and in many cases himself makes, the "wheels go round", and finds out what makes 'em go. Perhaps we have the prize winner for the new name here tonight. Perhaps one of our Medalists can prove himself an all 'round man by winning this additional prize—our sincere thanks, coupled with the inner satisfaction of knowing that he has made a most worthwhile contribution. Our so-called Museum embraces other activities than exhibits which are in process of reconversion study: semi-formal classes for increasing the understanding of workers in factories and others in the modern concepts of physical science. The Franklin Institute was founded in 1824 "for the promotion of the Mechanic Arts."

I mentioned the research. Everybody these days seems to be conscious of the word. One of the largest manufacturers of less expensive lines of womens' so-called hats says in last week's Saturday Evening Post, "We do research and we have a clipping book. The clipping

book consists of millinery advertisements from high-price retail stores. We have spotters out in the stores and around"—he whispers mysteriously. "We watch how hats are selling." With us at Franklin Institute, research is perhaps our prime of reconversion efforts. I told you something about our plans on this occasion last year. They have now started on their way. We have 120 workers in our new Laboratories exclusive of the shops. The official name is The Franklin Institute Laboratories for Research and Development; but this long title is already being shortened in conversation to the Franklin Laboratories, not only as a less ponderous name, but to indicate that it is co-existent and cooperative with the Bartol Foundation, both laboratories being parts of the one Franklin Institute. The Franklin Laboratories are now organized with three Divisions:—Instruments and Electronics, Mechanical and Civil Engineering, and Chemical Engineering and Physics. Each Division has a capable director, and all are under the eagle eye of an aggressive Executive Director. While our principal clients are still the Army and Navy, we're now in process of taking on work for industry and expanding our facilities accordingly. But so long as there is need for military preparedness we plan to devote a quarter part of our effort to that end.

Our new Laboratories are being launched into the world in the hard way—they have to earn their own way. Further, they are expected to help pay the cost of operating the Museum.

Fortunately there was space available in this building for a start at some sacrifice of museum space. Already, without asking, a gift has come in to equip a room for optical stress analysis and metallography. We will soon need an additional wing to this building and further equipment. We have every hope that the usefulness of the Franklin Laboratories to industry and as a means for supporting the Institute's educational activities will encourage further gifts.

Reconversion of our several other activities is planned to take place as fast as we can pay the bill. However I do want to point out that all of them are of such a nature that they contributed in some degree to the war effort, and hence have been kept up to the times, although not expanded.

I want to say just a word about one of these, our National Franklin Committee, which started after our dedication as the Franklin Memorial, for reincarnating the example of Benjamin Franklin. We can claim some part in a recent incident in China. In a particularly bitter dispute between two Chinese factions General Marshall, who had Franklin's writings with him, had that man's decisive Constitutional Convention speech translated into Chinese and distributed. General Marshall reported the results as salutary.

Just one more word about Reconversion. Our Science and Arts Committee has recently been examining its system for insuring the most deserving medal recipients. But judging by the medalists past and

present here this evening, I see, Mr. President, no reason for worry on that score.

Mr. President, with yours and the Board of Managers individual and collective unselfish service, the active interest of our members, with our fine staff, and with the support of the public, The Franklin Institute will not merely reconvert but will write a new and glorious chapter in its long and honorable story of useful service to the community, country, and world.

AWARD OF MEDALS.

MR. REDDING: At this point in the program may I address briefly those who tonight are to receive The Franklin Institute's Certificate and Medals. You may have wondered just how the Institute selects those to whom its marks of recognition are to be presented. That selection is a careful and painstaking process carried on by the Institute's Committee on Science and the Arts—a committee composed of some sixty-five selected members of the Institute who give unselfishly of their time in studying modern researches and developments in order that those who are doing and have done outstanding work may receive the public recognition afforded by a Franklin Institute award. It operates through sub-committees reporting to the main body. Recommendations for awards are made by the sub-committees to the main committee only after careful study and consideration by the members of the sub-committees. After recommendations are received by the main committee they are again fully and frankly discussed and if acted upon favorably, they are forwarded to the Board of Managers of the Institute for final action. So, I can say to you gentlemen who tonight are to receive awards, they have not been made lightly—we know that you fully deserve them. In giving them, we honor you, and in accepting them, you honor us.

MR. REDDING: The Chair recognizes Mr. Edward L. Forstall.

MR. FORSTALL: Mr. President, The spacing in conventional typewriters is the same width for all letters, and consequently the type is a compromise design accommodating wide letters such as "w" and "m" and narrow letters such as "i" and "t" to uniform spacing.

The Proportional Spacing Typewriter, considered in the present award, corrects this condition by an ingenious mechanism which varies the spacing proportionately to the normal widths of different letters, and the type is consequently designed accordingly; as is customary in printing type and is familiar to all in the printed page.

Also it gives the typed sheet a pleasing appearance, resembling the printed page.

An expander control permits changing the spacing between the letters from close together to wider spacing when preferred, especially for display purposes.

I present Mr. Ronald D. Dodge, of International Business Machines Co. to whom has been awarded a Certificate of Merit, reading:

"In consideration of the skill in design and development of the mechanism of the Proportional Spacing Machine."

MR. REDDING: Mr. Dodge, by virtue of the power vested in me as President of The Franklin Institute of the State of Pennsylvania, I present to you this Certificate of Merit and copy of the report which accompanies it.

MR. REDDING: The next sponsor, Mr. Ralph H. McClarren.

MR. MCCLARREN: Mr. President, as is well known, airplanes frequently have to be flown during weather conditions which cause ice to form on them.

Ice may form to such excessive weight as to cause serious accidents. And scheduled flights have had to be cancelled when such conditions were known to exist.

Means of breaking up ice as it forms have heretofore been devised, and have been used with considerable but not with sufficiently complete and dependable success under all icing conditions.

With the advent of global air operations prevention of icing on wings, control surfaces, propellers and windshields has become of increasing importance.

Our Medalist, in his work with the National Advisory Committee for Aeronautics, has developed a thermal method of preventing ice formation by circulating hot exhaust gases from the engines to heat body and wing surfaces and keep them free from icing.

I present Mr. Lewis A. Rodert for award of a John Price Wetherill Medal, upon citation reading:

"In consideration of his important and applied work in developing a thermal ice prevention system for airplanes."

Mr. Rodert, by virtue of the power vested in me as President of The Franklin Institute of the State of Pennsylvania, I present to you the John Price Wetherill Medal, the Certificate and copy of the Report which accompanies it.

MR. REDDING: Mr. Coleman Sellers, III.

MR. SELLERS: Mr. President, It is obvious that the behavior of soils under the foundations of heavy structures such as large buildings, dams and subways is a matter of great engineering importance in their construction and for their permanence and safety.

Accurate ascertainment of soil behavior under such heavy structures after their erection has been difficult.

Our Medalist's researches in the laboratory and in the field have enabled him to develop theories and mathematical formulae, confirmed by practical demonstrations, which have added greatly to our knowledge of soil compression, bearing capacities of soils, effect of drainage and of distribution of load throughout the soil bottom.

He has made results of his work available to engineers by publication of two volumes on the subject and over 100 technical papers.

I present Karl Terzahgi to whom has been awarded a Frank P. Brown Medal, upon citation reading:

"In consideration of his theoretical and technical knowledge, initiative, pioneering research and outstanding leadership in the establishment of the Science of Soil Mechanics."

MR. REDDING: Dr. Terzaghi, by virtue of my office, I present to you the Frank P. Brown Medal, and the Certificate and Report which accompany it.

MR. REDDING: I now call upon Mr. J. V. B. Duer.

MR. DUER: Mr. President, Application of roller bearings to locomotives involved unusual complications which made it a very difficult problem.

Our Medalist, by his ingenuity and engineering leadership, pioneered in their application to locomotives, and also to cars; as well, in the use of high strength steel in driving rods and reciprocating parts.

He was instrumental in the development of machines for testing the fatigue resistance of full-sized axles and crank pins; which tests resulted in fundamental design improvements in these parts. He also developed a technique of photographing and measuring the stresses in a locomotive under slipping conditions.

During an active career he has secured over one hundred United States patents; most of them in connection with the application of roller bearings to vehicles.

I present Mr. Tracy Vero Buckwalter, to whom has been awarded a George R. Henderson Medal, upon citation reading:

"In consideration of his accomplishments in applying anti-friction bearings to railroad locomotives and cars, thus contributing to the increase in reliability and decrease in maintenance costs of modern railroad equipment."

MR. REDDING: Mr. Buckwalter, as President of The Franklin Institute, I have much pleasure in presenting to you the George R. Henderson Medal, Certificate, and copy of the Report. We are deeply grateful to you for coming from Florida to receive this award; and to your many friends who are here to aid us in paying honor to you.

MR. REDDING: The next sponsor, Mr. Eugene W. Boehne.

MR. BOEHNE: Mr. President, The Louis Edward Levy Medal is awarded each year to the author of a paper of especial merit published in the JOURNAL of The Franklin Institute, preference being given to one describing the author's experimental and theoretical researches in a subject of fundamental importance.

The world has been enriched by the knowledge of our universe acquired by the astronomer, with the aid of the telescope and auxiliary equipment. In recent years, however, the range of reception of radiations from outside the earth has been broadened by the use of special

radio receivers. Hence the scientific *ear* comes to supplement and enhance what the scientific *eye* has taught us regarding our cosmic neighbors. Microwave radiations, so familiar to us in the applications of radar, are capable of penetrating the ionized layers which surround our earth; and hence, sources of such radiation external to the earth may be studied.

The paper entitled "Microwave Radiations from the Sun," has been selected for this year's award. This paper includes a quantitative investigation of microwave radiations from the sun as well as a sound theoretical treatment of this phenomenon.

I present Dr. George C. Southworth, of the Bell Telephone Laboratories, to whom has been awarded a Louis Edward Levy Medal, upon citation reading:

"For his paper 'Microwave Radiations from the Sun,' which appeared in the April 1945 issue of the Journal of the Franklin Institute."

MR. REDDING: Mr. Southworth, by virtue of my office, I present to you the Louis Edward Levy Medal, and Certificate and Report which accompany it.

MR. REDDING: Sponsor for the first Potts Medal, Mr. W. H. Fulweiler.

MR. FULWEILER: Mr. President, The application of the spectroscope to astronomical problems is one of the romantic chapters in the development of modern science.

How a tiny beam of light that started long before the dawn of recorded history, today reveals the composition of the emitting body is indeed a triumph of mind over matter.

It was early noted that certain lines observed in the spectra of the nebula and in the sun's corona could not be identified with any of our terrestrial elements and were attributed to hypothetical elements nebulium and coronium.

With the development of modern atomic theory, there has been a growing belief that these lines might be due to familiar elements existing under unfamiliar conditions.

We are today honoring two scientists who have worked in this interesting field of spectroscopy.

The Medalist I shall present brought to this problem a vast amount of knowledge gained from his work in the extreme ultra violet and by a most judicious mixture of science and Sherlock Holmes intuition, evolved an answer that has won the acclaim of the scientific world.

His solution indicates that these hitherto unidentified lines in the spectra of the nebula are due to oxygen and nitrogen, constituents of our atmosphere, under conditions that so far cannot be duplicated in the laboratory. In addition to solving this problem, he has made many other noteworthy contributions to the science of spectroscopy.

I present Ira Sprague Bowen of Pasadena, California, to whom has been awarded a Howard N. Potts Medal, upon citation reading:

"In consideration of his brilliant analysis of the problem of the identification of the so-called 'nebulium lines' which is based on modern atomic theory and on his own work in the extreme ultra violet."

MR. REDDING: Dr. Bowen, by power vested in me as President of The Franklin Institute, I have the honor of presenting to you the Howard N. Potts Medal, the Certificate and the Report. We are very grateful to you for taking the long journey to be with us tonight.

MR. REDDING: Again Mr. Fulweiler (Dr. W. R. Wright, sponsor, was ill).

MR. FULWEILER: Mr. President, The Medalist whom I shall have the honor to present had devoted himself to the study of the spectra in the extreme ultra violet of atoms whose normal makeup has been altered by the action of strong electric fields and high temperatures.

The data he has obtained have enabled him to arrive at a complete and detailed explanation of these coronal spectral lines in terms of highly ionized atoms of iron, nickel and calcium.

His work opens the way for a thorough revision of theories relating to stellar radiation and will undoubtedly be regarded as one of the milestones in progress of astrophysics.

I present in absentia Bengt Edlén of the University of Upsala, Sweden, to whom has been awarded the Howard N. Potts Medal, upon citation reading:

"In consideration of the light which his researches on the spectra of high excitation ions in the extreme ultra-violet have thrown on the problem of the corona, a contribution which has already stimulated other research on solar problems and promises to influence further work in the field for years to come."

MR. REDDING: Professor Edlén wrote to express his appreciation of this award and was disappointed that he could not arrange his affairs to come and receive it in person. Mr. Secretary, may I ask you to receive it in his behalf, and see that it is forwarded to him promptly? (Dr. Allen, Secretary of the Institute, received the medal to forward to Professor Edlén.)

MR. REDDING: The third sponsor for a Potts Medal, Mr. Francis G. Tatnall.

MR. TATNALL: Mr. President, The power delivered by a gas engine depends upon the amount of air and gasoline vapor that can be drawn into the cylinders.

This is at a maximum at sea level and decreases in the highly rarified air of high altitudes.

By compressing air to sea level density the sea level conditions and thus the power of the engine can be maintained as altitude increases.

Our Medalist by vision and persistence overcame many obstacles in designing a means for this, known as a Turbosupercharger, in which a turbine driven by exhaust gases from the engine operates a compressor which compresses the air drawn into the cylinders. These turbines operate at speeds up to 30,000 RPM and at temperatures up to 1500°F.

Ordinary metals cannot stand such conditions of stress and temperature, and therefore our Medalist very earnestly urged metallurgists to produce metals capable of withstanding them, and they did so.

The supercharger was thus designed and made a reliable part of the airplane power plant.

I present Sanford A. Moss, of Lynn, Massachusetts, to whom has been awarded a Howard N. Potts Medal, upon citation reading:

"In consideration of the extreme value of his work in making a Turbosupercharger a successful and reliable part of an internal combustion aeronautical engine."

MR. REDDING: Dr. Moss, I have much pleasure in presenting to you the Potts Medal, together with the Certificate and Report which accompany it.

MR. REDDING: The sponsor for the Cresson Medal, Dr. Rupen Eksergian.

DR. EKSERGIAN: Mr. President, The Medalist I have the honor to present is an Ordnance expert whose ability was developed through a long and diligent study of ordnance materiel.

His contributions in the field of design covered notable developments in seacoast artillery and anti-aircraft guns, including the introduction of all-welded gun carriages.

With this background and experience, he was appointed Chief of Research and Development Service of the Ordnance Department, U. S. A. This responsibility was ably carried out during the war in the coordination of American industry in the fabrication of ordnance materiel with outstanding leadership in engineering judgment.

I present Major General G. M. Barnes, to whom has been awarded an Elliott Cresson Medal, upon citation reading:

"In consideration of his notable contributions to the design and development of numerous ordnance items, particularly anti-aircraft guns; tanks; and seacoast artillery; for his early development of welded gun carriages; and for his masterly organization of ordnance research, closely articulated with development and production."

MR. REDDING: General Barnes, because of your close association with the work of The Franklin Institute during the war years, it gives me particular pleasure to present to you the Elliott Cresson Gold Medal, our oldest award, and the Certificate and Report which accompany it.

AWARD OF FRANKLIN MEDALS.

MR. REDDING: We now come to the award of the Institute's highest honor—the Franklin Medal, of which two will be presented tonight. I recognize Dr. Frederic Palmer, Jr.

DR. PALMER: Mr. President, I have the honor to present as a candidate for the Franklin Medal, Henry Clapp Sherman, for nineteen years Mitchill Professor of Chemistry, Columbia University, and at present Chief of the Bureau of Human Nutrition and Home Economics, United States Department of Agriculture.

The attention of the public was first drawn to Professor Sherman more than forty years ago when he, with Professor Atwater, of Wesleyan University, Middletown, Connecticut, measured the nutritional requirements of the contestants in a six-day bicycle race in Madison Square Garden. Since that time he has persistently applied the strictly quantitative methods of organic analysis to the determination of the different amounts of iron, calcium, magnesium, phosphorus and other elements needed to maintain normal bodily health. A check against the amounts actually consumed by people in various walks of life proved, in many cases, that these were inadequate. Hence Professor Sherman devised means to remedy the situation. Through his public lectures in many parts of the world, through his books and his activities in Government service he has done much to make the public conscious of dietary deficiencies, and to correct them.

Through prolonged experimentation, with the assistance of his students, he has shown that a diet containing several times the amount of nutritional factors found to be merely adequate tends to bring about earlier maturity and to postpone the onset of old age. Thus such a diet, which may be described is these respects as optimal, is definitely superior to a diet which is merely adequate.

His laboratory has contributed much to our knowledge of the enzymes, those remarkable catalysts in the digestive processes which split up thousands or even millions of times their own weight of starches and make sugars.

As for the vitamins, you, Professor Sherman, began your work in this field when there existed little but a chaos of conflicting qualitative information and you have transformed it into an orderly new science of steadily increasing importance to the well-being of mankind.

Hence, Mr. President, in consideration of his many contributions to the science of Nutrition and especially of his many public services as a result of which the general health level of millions of human beings all over the world has been uplifted, I take pleasure in presenting Henry Clapp Sherman.

MR. REDDING: Dr. Sherman, by virtue of the power vested in me as President of The Franklin Institute, I have the honor, and the pleasure,

to present to you our highest award, the Franklin Medal, with Certificate and Report; and this Certificate of Honorary Membership bestowed upon you by the members of the Institute.

Dr. Sherman is going to address us for a few minutes on the topic, "Research for Better Nutrition."* It is not necessary for me to introduce him beyond what you have heard in the citation which has just been given. Dr. Sherman.

RECIPIENTS OF AWARDS FOR 1946.

Seated (left to right): Sanford A. Moss (Potts); Henry Clapp Sherman (Franklin); Charles S. Redding, President, The Franklin Institute; Gladeon M. Barnes (Cresson); Tracy Vero Buckwalter (Henderson).

Standing (left to right): Lewis A. Rodert (Wetherill); George Clark Southworth (Levy); Henry Butler Allen, Secretary and Director, The Franklin Institute; Karl Terzaghi (Brown); Ira S. Bowen (Potts); Ronald D. Dodge (Certificate of Merit).

Absent: Sir Henry Thomas Tizard (Franklin); Bengt Edlén (Potts).

MR. REDDING: (After Dr. Sherman had read his paper) Thank you, Dr. Sherman. The final award is also a Franklin Medal . . . Mr. LePage.

MR. LEPAGE: Mr. President, I have the honor to present to you, as a candidate for the highest award made by The Franklin Institute, a man of great distinction in the field of aeronautics.

* See page 1 for "Research for Better Nutrition."

Sir Henry Tizard is the man who thirty years ago first brought to the art of aeronautics and aeronautical design, exact scientific method. To him belongs the credit for establishing the fundamentals of aircraft performance, prediction and measurement. To him is properly ascribed the credit for scientifically and mathematically laying down the basic principles of airplane design insofar as the important element of wing characteristics is concerned. And upon him has rested the responsibility for guiding British aeronautical research and development during the recent most critical years of our history, a responsibility carried to outstanding success by the sheer weight of a calm and deliberate personality supported by an unusual technical ability and capacity for self-effacing leadership.

This remarkable British scientist, who has received royal recognition for his work in and contributions to aeronautics, is likewise distinguished for his researches in physical chemistry. His genius in applying a fundamental acquaintance with physico-chemical phenomena to the problems of aeronautics has resulted in important advance in the solution of problems of fuel consumption in aircraft engines and in the development of new methods of fuel combustion and, consequently, new types of engines.

From 1939 on through World War II he was charged with the tremendous responsibilities of inspiring the leading aeronautical research and developments in Great Britain, whereby the air power of the Allied Nations was greatly enhanced.

Sir, upon citation which reads: "In recognition of his outstanding contributions which have advanced the science of aeronautics in the fields of full scale flight test procedure and internal combustion engines relating to fuel economy and for his leadership in aeronatutical research and development which in part involved the development of special devices for air offensive operations and for defense against an attack," I present to you, in absentia, Sir Henry Thomas Tizard, K.C.B., F.R.S., President of Magdalen College, Oxford, as a candidate for the Franklin Medal. The Medal will be received by Dr. Henry Butler Allen, Secretary and Director, The Franklin Institute.

MR. REDDING: It is our custom, in connection with the presentation of the Franklin Medal to a foreign recipient who is unable to be with us, to invite his country's ambassador, or his representative, to receive the medal and forward it to the recipient.

Sir Henry had expected to be with us but at the last moment difficulties of travel made it impossible for him to come. Lord Halifax, unable to attend himself, graciously appointed one of his staff to be present. A food conference kept that gentleman in Washington, so in these circumstances we ask Dr. Allen as Secretary of The Franklin Institute to receive the medal and see that it is transmitted to the British Embassy to be forwarded to Sir Henry in the diplomatic pouch.

Mr. Redding then explained that Sir Henry had prepared a paper which he would have presented himself if he had been with us. He called upon Mr. LePage who read the address entitled, "Teamwork in Research."*

After the playing of "America" by Captain Marriner, Mr. Redding expressed appreciation to all who participated in the exercises and declared the meeting adjourned.

NEW MEMBERS OF THE FRANKLIN INSTITUTE ELECTED DECEMBER 1, 1945 TO JUNE 1, 1946.

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* See page 5 for "Teamwork in Research."

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COMMITTEE ON SCIENCE AND THE ARTS.

(Abstract of Proceedings of Stated Meeting held Wednesday, June 12, 1946.)

HALL OF THE COMMITTEE,
PHILADELPHIA, JUNE 12, 1946.

DR. HIRAM S. LUKENS, *in the Chair.*

The following report was presented for final action:

No. 3141: Razek-Mulder Color-Analyzer.

This report recommended the award of a Certificate of Merit each to Joseph Razek, of Llanerch, Pennsylvania, and Peter J. Muler, of Shippensburg State Teachers College, Pennsylvania, "In consideration of their perfection of a means for making rapid, automatic color comparisons and analyses of opaque and translucent materials, and of light sources."

JOHN FRAZER,
Secretary to Committee.

LIBRARY NOTES.

The Committee on Library desires to add to the collections any technical works that members would wish to contribute. Contributions will be gratefully acknowledged and placed in the library. Duplicates received will be transferred to other libraries as gifts of the donor.

Photostat Service. Photostat prints of any material in the collections can be supplied on request. Orders received in the morning are filled the same day. The average cost for a print 9 × 14 inches is thirty-five cents.

The library and reading room are open on Mondays, Tuesdays, Wednesdays, and Fridays from nine o'clock A.M. until five o'clock P.M., Thursdays from two until ten o'clock P.M., Saturdays from 9 o'clock A.M., until 12 noon as of June 1, 1946.

RECENT ADDITIONS.

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NOTES FROM THE BIOCHEMICAL RESEARCH FOUNDATION.

Monochromatic Light Absorption by Normal Chicken Erythrocytes.—J. O. Ely and M. H. Ross. The relative absorption of different wave lengths of monochromatic light by the nuclei of chicken erythrocytes was determined with equipment and technic similar to that used by Allen, Franklin and McDonald (1). The maximum absorption by the nuclei of the various wave lengths used was found to be at 2804 Å. This differs somewhat from the maximum nuclear absorption of tumor nuclei found by the above-mentioned investigators, who found a maximum absorption at 2500 to 2600 Å for a rat sarcoma. Gates (2) found that a maximum absorption of monochromatic light by *Staphylococcus aureus* and *Escherichia coli* was between 2600 and 2700 Å. Weinstein (3) found that the maximum killing effect on paramecia of different wave lengths of monochromatic light was at 2800 Å. The killing effect may be assumed to be correlated with maximum absorption since they occur at the same wave length; it appears, therefore, that the maximum absorption of the nuclei of different kinds of cells may be at different wave lengths.

The methods used in these studies were as follows. Thin cover-glass smears of whole chicken blood were made on quartz cover-glasses. The smears were air-dried, then immersed in 95 per cent. ethyl alcohol for approximately 5 seconds, and then mounted on quartz slides with glycerol of 1.455 refractive index as the mounting medium. The edges of the preparation were then sealed with paraffin.

Photomicrographs were taken of a suitable microscopic field using an all-quartz optical system microcsope. Eastman Kodak Company Panatomic-X 35 mm. film was used and developed in Eastman Kodak Company developer D-19. Enlargements were made in the usual manner.

The source of light was a quartz mercury-vapor lamp similar in construction to that described by Allen, Franklin and McDonald (1). A quartz monochromator was used to divide the light spectrum into bands.

Darkening of the nucleus in the photomicrographs is an indication that the nuclear material absorbed light at that wave length. The darkening in the photographic image of the nuclear material by light absorption produces an effect in the pictures resembling the effect obtained by staining of the nuclear material prior to photography with ordinary light.

The photomicrographs (Figs. 1a and 1b) show that there was very little absorption of light by the nuclei at the wave lengths 4350 Å, 3654 Å, and 3022 Å. Beginning at 2894 Å and extending to 2483 Å the

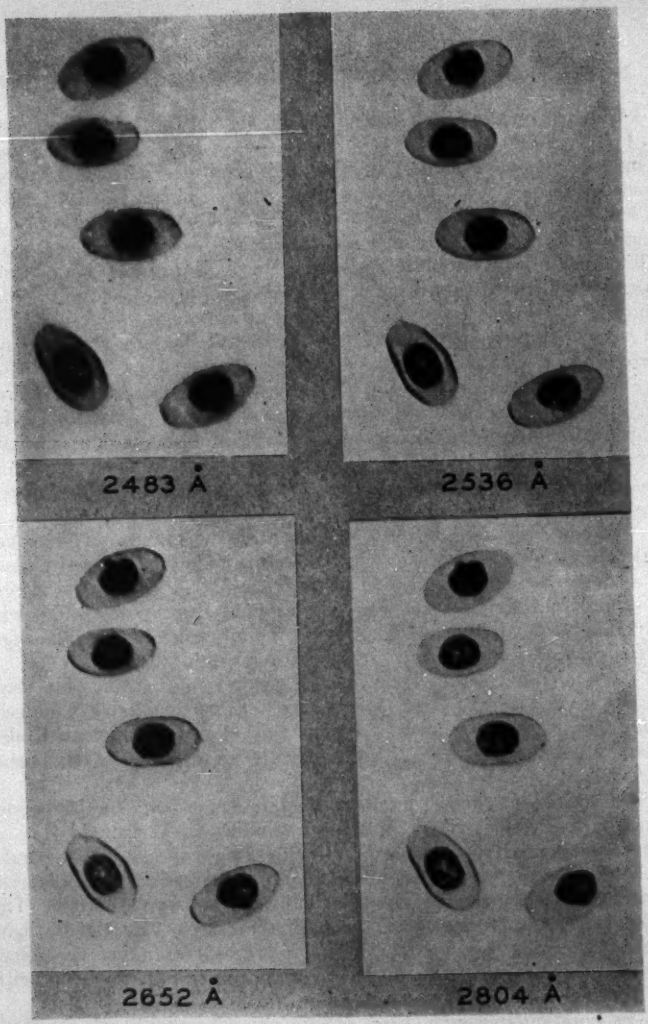

Fig. 1a. Absorption of monochromatic light by chicken erythrocytes.

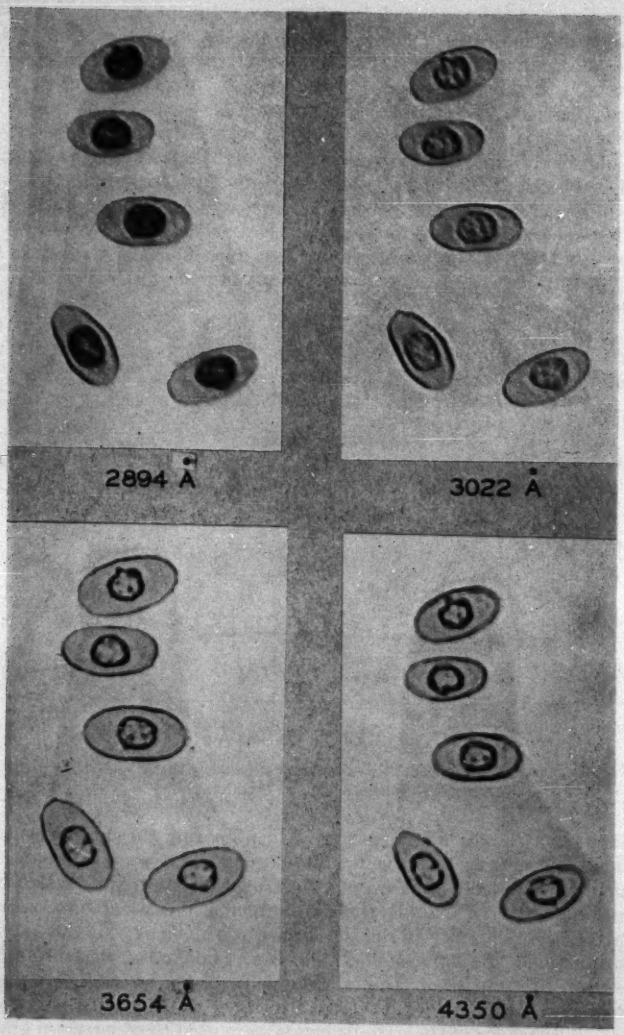

FIG. 1b. Absorption of monochromatic light by chicken erythrocytes.

absorption of light was much greater. Visual inspection of the photomicrographs indicates that the maximum absorption of the nuclear material occurred at 2804 Å. The photomicrographs indicate that the cytoplasm of the cells absorbed very little light at the different wave lengths studied.

Verification of the relative absorption at the different wave lengths was obtained by use of a microdensitometer. This apparatus designed by Dr. Theodore Enns of this laboratory (the construction and operation to be described by him at a later date) was used with a microscope so that microscopic fields as small as the nuclear images could be examined. The relative density of 10 nuclei in each negative taken at the

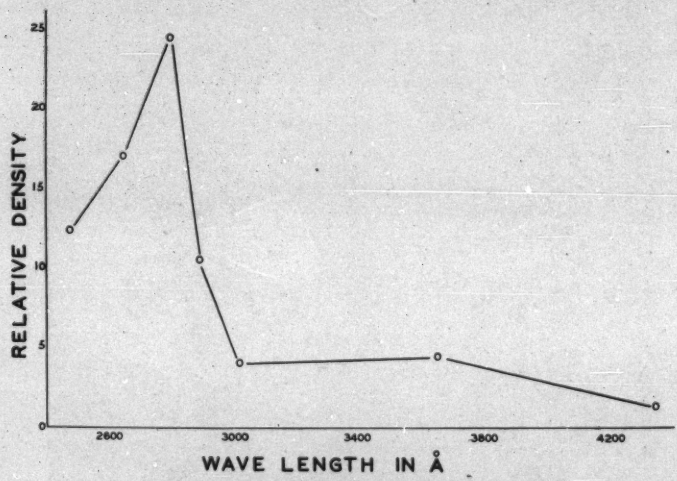

FIG. 2. The Relative absorption of monochromatic light by the nuclei of chicken erythrocytes.

different light bands was measured. In preparing the negatives to be studied, the same microscopic field was used at each wave band and the exposure so adjusted that negatives of over-all approximate densities were obtained. In making the densitometric measurements on each negative, the difference in density between a nucleus and the average of four areas of the film outside the cell was taken as a measure of the density of that nucleus. The average value obtained for the 10 nuclei measured at each band was taken as a measure of the absorption of that band. The values of the various bands were used to construct a graph, Fig. 2, showing the relative absorption by the nuclei at the wave lengths used. It may be seen that the maximum absorption by the nuclear

material of the erythrocytes was at 2804 Å and that there was relatively little absorption at 3022 Å and above. The use of the densitometer verified the results seen in the photomicrographs and eliminated the uncertainties accompanying the use of only photographs for this purpose.

These studies were undertaken for the purpose of developing a method to be applied to the investigation of the metabolic changes which take place in the nucleic acid molecule and if possible to identify by means of spectroscopy the type of nucleic acid of the cell nucleus. Such studies are now in progress.

Summary. The maximum absorption of monochromatic light by the nuclei of normal chicken erythrocytes was found by the method of photomicrography to be at 2804 Å. This finding was confirmed by the use of a microdensitometer recently designed at the Biochemical Research Foundation (to be described at a later date).

This procedure developed for the determination of absorption of monochromatic light in the nucleus is being applied in the study of metabolic changes in the nucleic acid molecule.

REFERENCES.

(1) ALLEN, A. J., FRANKLIN, R., AND MCDONALD, E., *J. Franklin Inst.*, **218**, 701 (1934).
(2) GATES, F. L., *J. Gen. Physiol.*, **14**, 31 (1930).
(3) WEINSTEIN, I., *J. Optical Soc. America*, **20**, 433 (1930).

BOOK REVIEWS.

THE CAVENDISH LABORATORY, by Alexander Wood, 59 pages, plates, 10 × 17 cms. Cambridge, University Press, 1946.

Among the outstanding physics laboratories of the world is the Cavendish Laboratory in England at Cambridge University. The establishment of this laboratory was first recommended in 1869 and its financing was soon assured through the generosity of the 7th Duke of Devonshire, then Chancellor of the University, whose family name of Cavendish was also borne by the illustrious physicist of the eighteenth century Henry Cavendish. A professorship was established in 1871 and the building was formally opened in 1874.

James Clerk Maxwell, Lord Rayleigh, John Joseph Thomson, Lord Rutherford, and the present incumbent, Sir Lawrence Bragg, are the distinguished scholars who have held the Cavendish professorship. The research done at the laboratory reflects the calibre of its leaders and the assistants whom they have gathered around them. Vital work has been done here, especially on radioactivity and atomic research.

Physically a small book, this is a readable account of the development and contributions of this well-known laboratory.

G. E. PETTENGILL.

COLLOID CHEMISTRY, Theoretical and Applied, collected and edited by Jerome Alexander. Volume 6. 1215 pages, illustrations, tables, diagrams, 15 × 23 cms. New York, Reinhold Publishing Corporation, 1946. Price $20.00.

This sixth volume of "Colloid Chemistry" marks the completion of the first supplement to the original work of four volumes. The 71 papers in this volume, dealing primarily with the industrial applications of colloid chemistry, are grouped in two parts. Part I includes papers treating of general principles and of specific industries, while part II is devoted to synthetic polymers and plastics.

The varied applications of colloid chemistry discussed can be perceived by a reading of the titles of the various articles, for example: "The Colloid Chemistry of Insecticides" by O. A. Nelson and C. M. Smith; "Principles and Practice of Soil Stabilization" by Hans F. Winterkorn; "Physical Chemistry of Dyeing" by E. I. Valko; and "Synthetic Rubber" by E. A. Hauser and D. S. le Beau. The mass spectrometer, the Geiger-Muller X-ray spectrometer and the electron microscope are each discussed and their applications considered.

The thirty-two articles on synthetic polymers and plastics cover a wide variety of types, while the standing of the authors will likewise make this a valuable contribution to the rapidly growing literature on plastics. The editor has contributed a final article on "Potential Nuclear Energy and Some Consequences of its Release."

Although the articles vary in length from a mere two pages on casein plastics to a monograph of over one hundred pages on "Phycocolloids: Useful Seaweed Polysaccharides" by C. K. Tseng, the value of these authoritative reviews with their accompanying bibliographies cannot be questioned.

G. E. PETTENGILL.

ELEMENTS OF AMMUNITION, by Major Theodore C. Ohart. 412 pages, illustrations, 15 × 23 cms. New York, John Wiley & Sons; London: Chapman & Hall, Limited, 1946. Price $6.00.

When the need arises for a large use of ammunition, a great many workers are required. Most of these are newcomers in the field and must gain knowledge rapidly, early in the emergency. In our most recent experience this could have been done with greater ease if a book were available to study and absorb quickly the essence of what they would need to know to handle their jobs. The book at hand was written to fill such a need.

The information presented is strictly from the ammunition designer's point of view in contrast to existing technical bulletins which have the viewpoint of the user. Likewise, the beginner is kept in mind rather than the experienced ammunition man, so that understanding is made clearer. The book is divided into seven parts, each distinct in itself. The first, on explosives, primers, detonators, and tracers, starts with definitions of general types of weapons and ammunition before going into the explosive half of ammunition. In the later section of this part, the design of primers and detonators for the explosive train is treated separately. Small arms ammunition forms the second subject of the book. This includes that used by individual soldiers and as aircraft and tank armament, with bore of 0.60 in. or less. Part three is devoted to artillery ammunition. This is divided into sections on a description of projectiles, fuzes and boosters, and artillery complete rounds. Aircraft ammunition is next taken up which is defined as ammunition dropped from aircraft or as ammunition peculiar to aircraft. Bombs and bomb fuzes make up this part, which is followed by space devoted to pyrotechnic ammunition. This is defined as components or devices primarily for either signaling or illumination. There is a chapter on rocket ammunition which is "merely an attempt to give the reader some picture of this new and fascinating subject," according to the author. The final chapter is devoted to miscellaneous ammunition including grenades, rifle grenades, antitank mines, antipersonnel mines, booby traps, destructors, and other miscellaneous ammunition devices. There is a subject index in the back of the book which adds to its value as a reference work.

This is a valuable book to ordnance engineers and all those whose work is associated with military ammunition.

R. H. OPPERMANN.

YOU . . . AND THE UNIVERSE, by John J. O'Neill. 328 pages, 15 × 23 cms. New York, Ives Washburn, Inc. 1946. Price $3.50.

In 1936 during the Harvard Tercentenary Celebration, there was held the Arts and Sciences Conference the purpose of which was to bridge the expanding gaps between science and society and the advancing vanguard groups of scientists on the forefronts of knowledge. It was recognized that as each science becomes more complex it moves further from common understanding. The essential interpretation to the general public of the progress of science is being achieved in a manner improving with time, but the converse, the interpretation of society and its problems to science is an activity in which slow and uncertain progress is being made. Further, there is much confusion between workers in various fields of science where they are unable to understand each other such as between the physicist and the biologist, or the chemist and the astronomer.

The author of this book states that it would be well if such a conclave of scholars as the Harvard Arts and Sciences Conference could be held at least every decade for weaving the accumulated knowledge into an integrated pattern and especially if means were provided for interpreting the advanced erudition of the scientists in terms of everyday speech. The present volume is an effort to perform this service, covering that period which overlaps the Harvard Conference and extends to the events of today.

All of the material comprising this book was written for and published originally in the New York Herald Tribune. It is divided into two parts—of man and of the universe. The former deals with subjects of anthropology, archaeology, zoology, biology, physiology, medicine and psychology. The latter includes climate, geology, mathamatics, physics, electricity, engineering and chemistry, and astronomy.

The stories are interesting, informative, and cultural. The book is easily understood and is a contribution toward educating the layman on the progress and effects of science.

R. H. OPPERMANN.

OUR OIL RESOURCES, edited by Leonard M. Fanning. 311 pages, tables and illustrations, 14 × 21 cms. New York and London: McGraw-Hill Book Company, Inc., 1945. Price $4.00.

This important subject enters the lives of each and every one of us. Never has petroleum played a more vital role in our national life than it does today. And its supply for the service of mankind is inextricably bound up with the establishment and maintenance of peace throughout the world. This book is an impressive symposium of papers by the authors under the editorship of Leonard M. Fanning. The subjects treated on include the role of private enterprise in the development of oil resources; American oil companies in foreign peteroleum operations; conservation of our oil and gas resources; technology of exploration, production and refining; oil and gas reserves; coal and shale reserves, oil from coal and shale; oil in public domain, naval reserves and federal and state marginal lands; capital employed in the petroleum industry; and a final broad view of the industry including a post-war outlook.

The book presents a review of the vital points affecting our oil resources given by authorities. It provides much food for thought by the layman and those in the industry as well as those in and associated with public bodies having to do with the industry.

R. H. OPPERMANN.

THE ELECTRON MICROSCOPE, An Introduction to its FundamentalP rinciples and Application, by E. F. Burton and W. H. Kohl. Second Edition. 326 pages, drawings and illustrations, 16 × 23 cms. New York, Reinhold Publishing Corporation, 1946. Price $4.00.

A large number of electron microscopes is now in use and a new science of electron optics has come into being. The increased resolving power and depth of focus are advantages which have enabled this instrument to make a place for itself in scientific research in many fields. The exposure of specimens to a vacuum and a rather intense electron beam are disadvantages which are taken into account in the interpretation of the final micrograph and offer a challenge to overcome. This book, which is the second edition, is written for the non-technical reader who is interested in modern techniques in the use of the electron microscope.

The work starts with a treatment on vision, illustrating the bending of light and the action of a lens. Then this is applied to the fundamentals of light microscopes. A short but very good treatment on the scientific theory of light, wave motion and wave motion media form the basis for a discussion on light waves and the microscope. This is followed by a similar basic treatment on the relationship of light, electricity and magnetism which is the background for coverages on the electron, its emission and motions of electrons in electrical and magnetic fields. Electron optics is described first under magnetic focussing, then electrostatic focussing, then the principles of electrostatic and magnetic electron microscopes are explained with a detailed description of the design, construction and operation of the instrument now in use at the University of Toronto.

The final chapters are devoted to useful magnification which depends on the limitations imposed by aberrations and structural deficiencies. Space is also devoted to preparation of the specimen, the production of the micrograph and the interpretation of the micrograph. The practical applications of the electron microscope are described and illustrated in many fields of activity and there are pointed out numerous limits of present knowledge where the electron microscope is likely to be an instrument in pioneering new territory.

The style of presentation, its logical sequence and the illustrations should make this book a valuable aid to new and present workers with the instrument.

R. H. OPPERMANN.

PUBLICATIONS RECEIVED.

The Engineer in Society, by John Mills. 196 pages, 14 × 21 cms. New York, D. Van Nostrand Co., Inc., 1946. Price $2.50.

Theory and Practice of Filtration, by George D. Dickey and Charles L. Bryden. 346 pages, drawings and illustrations, 16 × 23 cms. New York, Reinhold Publishing Corporation, 1946. Price $6.00.

Understanding Microwaves, by Victor J. Young. 385 pages, illustrations, 15 × 22 cms. New York, John F. Rider Publisher, Inc. 1946. Price $6.00.